Virtual insanity: Do students perform better in the classroom?

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This paper implements a difference-in-differences estimator to analyze Florida's policy of reinstating in-person instruction versus Georgia's policy of distance learning implemented during the height of the pandemic for the 2020-2021 school year. We analyze the virtual and non-virtual schools for grades 3 through 8 in both math and English learning outcomes. Virtual schools are schools that would normally contain virtual learning, and non-virtual schools are schools that would normally contain in-person learning. Additionally, we perform a triple difference estimator along with separate difference-in-differences calculations to determine the impact of the policy on socioeconomically disadvantaged and advantaged students.

1 Introduction

The COVID-19 pandemic led to an unprecedented impact on the US's public education system. From the implementation of distance learning to the establishment of new meal policies, public education continued to widely evolve. Several resources and databases have been created and analyzed such as the Nation's Report Card which revealed the negative impact on education outcomes such as math test scores; however, these resources are largely generalized and do not provide enough detail to understand the nuances that have caused these negative effects. Additionally, a scarcity of research has analyzed the actual impact of differing policies forcing virtual or non-virtual learning on education outcomes. Finally, has been a dearth of research studying the impact of these varying state policies corresponding with socioeconomically disadvantaged students. Therefore, this research would provide an insightful analysis into the relationship between the technology, learning, and socioeconomic status through the pandemic's impact on remote learning.

The pandemic was a major shock to the lives of all people around the world, which affected nearly all facets of life. Consequently, its impact on education coincided with a plethora of issues that led to a sparsity of good data during the peak years of the pandemic. Research was stunted during the pandemic as a result (DeMatthews et al. 2020, 3). This has led to an interesting gap in research that has not adequately addressed the before and after effects given the recent status of good data finally being collected from public schools. Therefore, questions regarding the education outcomes pose significant policy areas to truly understanding how to improve the education system. Several widely cited resources have analyzed the impact of various policies in other countries such as the transition to online education in Georgia, where there was notable success in online education (Basilaia, Giorgi, and Kvavadze 2020, 7). This reasoning reveals some interesting propositions concerning virtual versus non-virtual education that could be analyzed within the United States. Finally, regarding financial costs and funding, the majority of states' public schools have had a net decrease in education spending between 2009 to 2017, which have led to tangible deficiencies in schools' abilities to educate students (Baker, Bruce D., and Matthew Di Carlo 2020, 14-15); this may shed some light on the relationship between socioeconomic status and flexibility for education as there may be discrepancies in not only education level from parent to child which can negatively impact troubleshooting but affordability problems for new devices (Aguilar, Stephen J., Hernan Galperin, Clare Baek, and Eduardo Gonzalez 2020, 10-12).

Various states across the country adopted differing stances on how to react towards the pandemic but only recently are we fully understanding the ramifications of these decisions. After the mass shutdowns and social distancing in the initial stages of the pandemic in early 2020, some states reopened for the following school year while others continued distance learning. This period describes the difference in policy between Florida and Georgia. Florida reopened in-person instruction for the following 2020-2021 school year while Georgia continued distance learning for another year, only to reopen fully in the 2021-2022 school year. This paper will analyze the impacts of Florida's policy to reopen with regards to Georgia for virtual and non-virtual schools along with socioeconomically disadvantaged students.

We document 2 new findings to the research literature. First, we offer empirical support for Florida's policy of face to face instruction improving math and English scores through a difference-in-differences model. Second, we provide a triple difference estimator along with separate difference-in-difference models to provide insight towards how disadvantaged and advantaged students were similarly positively affected by the policy.

2 Literature Review

Research has rapidly focused on the efficacy of virtual and distance learning options though many countries developed their own policies to combat the negative outcomes of the pandemics's impact on education. Although mostly survey data, there has been a wide variety of research regarding the perceived factors that have determined learning efficacy from the perspectives of parents, teachers, and even students for primary, middle, secondary, and post-secondary education. However, one of the main limitations of primary, middle, and secondary education analysis during the pandemic was a lack of education data that could offer empirical support while most of the post-secondary education research focused on surveys due to the lack of publicly available learning outcomes data as well.

Much of the education research for post-secondary education during the pandemic focused on the effectiveness of virtual learning options through studies of other countries' policies. In both South Korea and India, various factors such as student motivation, course structure, and faculty knowledge similarly positively benefited students' satisfaction as learning outcomes were perceived as improving during online instruction (Baber 2020, 286-287). Some studies even suggested the notion that distance learning barriers included self-imposed, pedagogical, technical, and financial obstacles; consequently, in a survey administered to 400 professors and 600 students from various Arab universities, there existed barriers to learning efficiencies such as difficulty in communicating online for 82% of professors, internet speed issues for 80% of professors, 71% stating a lack of training, and even 66% indicating data privacy issues (Lassoued, Alhendawi, and Bashitialshaaer 2020, 10). Therefore, there exists significant drawbacks to online learning from the teachers' perspectives along with the students.

Unsurprisingly, distance learning continues to develop and has yet to achieve the same indispensability of in-person instruction through widespread willingness of students to learn online has contributed to the potential of e-learning opportunities to flourish, and in one Hungarian university case study, students were found to mostly satisfied with the online instruction offered (Ismaili 2020, 27). However, not all types of courses would necessarily be improved by distance learning. In Indonesia, distance learning using social media was effective for theoretical courses rather than practical and field courses (Nadeak 2020, 1769). In a psychological analysis of Indonesian university students, the results revealed that students became bored after the first 2 weeks of instruction, lower income students had more anxiety, and emotional disturbances occurred due to too many assignments deemed ineffective by students (Irawan, Dwisona, and Lestari 2020, 57).

One important and consistent drawback evident in the current literature is that lower income families would be negatively affected due to "unequal access to technology" and challenges to providing meals to free or reduced-price lunch students (Morgan 2020, 139). The effects of family further cascade as parental home-based environments more significantly impacted students' learning as 80% of Portuguese parents stated they made an effort to help their child with online learning, and the level of involvement decreases as students become older (Ribeiro et al. 2021, 16). Therefore, lower income families which tend to be less educated have more difficulty in aiding their children's' learning though creative solutions have drawn satisfaction in the community. As exhibited in one Norwegian community study for primary, middle, and secondary education, learning outcomes benefited as schools increased grassroots innovation in response to virtual instruction, and these efforts were perceived positively by both students and parents (Bubb and Jones 2020, 220). This movement enables a re-thinking of not only student teacher relationships but also teacher and parent. Although the current body of research has expanded on possible drawbacks and even creative positives to distance learning, most of the research literature utilizes survey data that largely extrapolates on the perceived efficacy of distance learning.

3 Data

This paper utilizes the Georgia Milestones End-of-Grade (EOG) Assessments data, Florida Standards Assessments data, and the National Center for Education Statistics' (NCES) data for school characteristics, membership, and lunch program eligibility. These publicly available data sets were connected by district code and institution number for both Florida and Georgia to determine school virtual status and proportion of students on free or reduced-price lunch (FRPL) programs. This data was then organized by grade and year for both states. The school years included were 2016-2017, 2017-2018, 2018-2019, 2020-2021, and 2021-2022. This paper will refer to each of these school years by their ending year: 2017, 2018, 2019, 2021, and 2022 respectively. Due to the pandemic, there was a paucity of data for the year 2019-2020, so the analysis skips this year; however, we assume that both states were affected similarly for that year as the pandemic shut down schools in both states around the same time. Additionally, we used data starting from 2016-2017 due to the NCES's "more nuanced" approach to determining the virtual status of schools beginning from that year. This resulted in 4 permitted categories of virtual status: full virtual, face virtual, supplemental virtual, and not virtual. For the purposes of this research, we only analyzed schools fitting into the category of either full virtual or not virtual. Full virtual schools are schools that would normally be online before the pandemic, and not virtual schools are schools that would normally be in-person before the pandemic. This paper will refer to these categories as simply "virtual" and "non-virtual" respectively.

Regarding education outcomes, this paper utilizes the established achievement levels of both states. In Florida, the achievement levels include 5 categories: level 1, level 2, level 3, level 4, and level 5. Level

3 and above are considered expected satisfactory or above satisfactory performance, so the percentage of students scoring in these ranges will be used for the comparison. In Georgia, the achievement level descriptors include 4 categories: beginning, developing, proficient, and distinguished. According to the state, proficient and distinguished learners meet or exceed the expectations of their grade level, so the percentage of students in these 2 categories will be used for the comparison. For both states, these satisfactory and above learners will simply be called "satisfactory learners" from now on. The subjects analyzed are math and English, and the grade levels include 3rd to 8th.

Finally, this paper analyzes the impact of Florida's policy to immediately reopen school in regards to socioeconomic factors by categorizing all schools within both states as either "disadvantaged" or "advantaged." According to the NCES, low poverty schools contain 25% or less students eligible for FRPL, and medium to low poverty schools contain 25.1 to 50.0 percent of the student body eligible for FRPL; medium to high poverty schools contain 50.1 to 75.0 percent of FRPL eligible students, and high poverty schools contain more than 75% of FRPL eligible students. For the purposes of this research, disadvantaged schools will contain more than 50% of FRPL eligible students, and advantaged schools will contain less than or equal to 50% of FRPL eligible students.

4 Methodology

4.1 Methods

We run a quasi experiment using difference-in-differences with Florida as the treatment and Georgia as the control to evaluate Florida's policy to re-open schools in the 2020-2021 school year, evaluating coefficients at the 95% confidence level; we analyze the test scores from the 2017, 2018, 2019, 2021, and 2022 school years. The treatment years begin in 2021, which is when Florida reopened schools while Georgia still did not require in-person instruction, to 2022. The years 2022 are considered part of the treatment years because we argue that Florida's decision to reopen schools in 2021 enabled the following years to be impacted as students were more accustomed to in-person instruction and would therefore be anticipated to do better than their Georgian counterparts. We evaluate this treatment for both virtual and non-virtual schools in both states. It should be noted that for all tables the treatment group contains a higher percentage of satisfactory learners due partially to the difference in achievement levels between states. Since Florida has 5 achievement levels as opposed to Georgia's 4 levels of achievement, Florida naturally contains more satisfactory learners. The grade levels are 3rd, 4th, 5th, 6th, 7th, and 8th. The measured subjects are math and English. For each grade level, we took the average of the percentage of satisfactory learners for all schools in both states, organized by virtual and non-virtual. School grade levels with less than 10 students were left out as their data was not recorded to protect the students' privacy. Florida represents the treatment group, and Georgia represents the control group:

$$Treat_t = \{Treat_{Florida} = 1, Treat_{Georgia} = 0\} \tag{1}$$

The years 2017, 2018, and 2019 were the pre periods, and the years 2021 and 2022 were the post periods:

$$Post_t = \{Post_{2017} = 0, Post_{2018} = 0, Post_{2019} = 0, Post_{2021} = 1, Post_{2022} = 1\} \tag{2}$$

For each grade level, we passed in the averages into our DiD equation:

$$Y_{st} = \beta_0 + \beta_1 Treat_s + \beta_2 Post_t + \beta_3 Treat_s * Post_t + \epsilon_{st} \tag{3}$$

In the second analysis, this paper utilizes a triple difference estimator (DDD) approach to understand the policy's impact on schools in terms of mid to high poverty schools to low to mid poverty schools while implementing a separate difference in differences (DiD) for disadvantaged and advantaged students. It should be noted this part of the analysis only deals with the non-virtual portion of schools as virtual data was much more sparse. Like in the DiD, our treatment and post periods are the same; however, we will now be adding in our third constraint representing the disadvantaged status:

$$D_a = \{D_{Yes} = 1, D_{No} = 0\} \tag{4}$$

Using our definition of disadvantaged and advantaged schools, we repeat the analysis for grades 3 through 8 using the following DDD equation:

$$\begin{aligned} Y_{sta} = \beta_0 + \beta_1 Treat_s + \beta_2 Post_t + \beta_3 D_a + \beta_4 Treat_s * Post_t + \beta_5 Treat_s * D_a \\ + \beta_6 Post_t * D_a + \beta_7 Treat_s * Post_t * D_a + \epsilon_{sta} \end{aligned} \tag{5}$$

For each grade level, we took the average of the percentage of satisfactory learners for all schools, organized by disadvantaged and advantaged status for both Florida and Georgia. Similarly to the DiD model, the schools with less than 10 students were not included. Afterwards, we also implement a normal DiD for both disadvantaged and advantaged subgroups for both math and English satisfactory learners. We simply plug into the original DiD equation, only now the outcomes being tested are in terms of these subgroups. We compare this analysis with the DDD analysis. It should be noted that the DDD analysis was implemented to test the robustness of the data in addition to comparing the results with the DiD.

Finally, for all of the below results, we will be using a significance level of 5% to determine statistical significance.

4.2 Key assumptions

1. The COVID-19 pandemic at the end of the 2019-2020 school year impacted both states equally.

2. The change in the control group (Georgia) is an accurate reflection of the counterfactual for the change in the treatment group (Florida) in the absence of the policy. We see that for grade levels, in the "clean" period before the school year 2020-2021, both states had similar trends for both virtual and non-virtual schools.

3. We employ the zero conditional mean assumption.

4. For the DDD model, using the substantiation provided by Olden and Møen, we can apply this model without using 2 parallel trend assumptions due to "two biased difference-in-differences estimators [being] unbiased as long as the bias is the same in both estimators," which we satisfy due to our previous assumptions (Olden and Møen 2022, 3).

5 Results

Tables 1 through 4 within the appendix contain the observation counts by grade for both Florida and Georgia virtual and non-virtual. Again, the observations are by school.

5.1 Difference-in-differences (DiD) non-virtual and virtual

We run 4 specific DiD models between Georgia (control) and Florida (treatment): non-virtual schools' English, virtual schools' English, non-virtual schools' math, and virtual schools' math. To reiterate, these learning outcomes are measured by the percentage of satisfactory learners for each state.

For non-virtual schools' English, there were no statistically significant differences between the Florida and Georgia in the post period for all grades.

For virtual schools' English, grades 6 and 7 displayed statistically significant results at the 95% confidence level. Florida's education outcomes were 15 and 8 percentage points higher for grades 6 and 7 respectively in the post period.

For non-virtual schools' math, there were no statistically significant differences between the Florida and Georgia in the post period for all grades.

For virtual schools' math, there were no statistically significant differences between the Florida and Georgia in the post period for all grades.

5.2 Triple difference estimator (DDD)

For the triple difference estimator, we focused on non-virtual students as the data was significantly sparser for virtual schools, and we reason that virtual schools would not be as affected by the policy as they are accustomed to virtual learning already. We analyze the effect of the policy for English and math learning outcomes on disadvantaged versus advantaged students for both Florida and Georgia to see if there is a difference in the difference-in-differences.

For the English DDD, only grade 4 was statistically significant at the 95% level for β_5 meaning that advantaged learners were better off with the policy with a 6 percentage point increase. β_6 and β_7, the DDD estimator, were statistically insignificant for all grades.

For the Math DDD, grades 4, 5, and 7 were statistically significant at the 95% level with 10, 7, and 3 percentage point increases for the advantaged cohort due to the policy. β_6 and β_7, the DDD estimator, were statistically insignificant for all grades.

5.3 Difference-in-differences (DiD) disadvantaged and advantaged

This sections contains the individual difference-in-differences for the disadvantaged and advantaged cohorts for both English and math testing. This will allow us to compare and better interpret our results from the DDD's initial results. We have 4 models for the non-virtual cohort: English disadvantaged DiD, English advantaged DiD, math disadvantaged DiD, and math advantaged DiD.

For the English disadvantaged DiD, none of the grades were statistically significant for the difference estimator.

For the English advantaged DiD, only grade 4 was statistically significant at the 95% level with a positive 6 percentage point change for English test scores due to the policy. This agrees with the output in the

English DDD analysis.

For the math disadvantaged DiD, none of the grades were significant for the difference estimator.

For the math advantaged DiD, only grade 6 saw a statistically significant increase of about 8 percentage points more with the implementation of the policy.

6 Discussion

Our results have shown some empirical support that Florida's policy to reopen schools earlier did help contribute to a positive impact for grade levels compared to Georgia for both math and English testing for non-virtual schools and even virtual schools; interestingly, virtual English test scores were higher in Florida than Georgia in the post period due to the policy for grades 6 and 7. Florida maintains several dozen virtual schools compared to Georgia which only has a few, which could possibly explain Florida being more equipped to handle virtual instruction. Although the data was much less significant for the virtual categories, they did show some change due to the policy, which could have occurred due to more advantaged students shifting into virtual programs during this time, artificially inflating the score. Regarding the disadvantaged and advantaged cohort, there was evidence to suggest that Florida's policy on non-virtual learning positively impacted socioeconomically advantaged students for both math and English learning outcomes while the disadvantaged cohort had no statistically significant outcomes for any grade at the 95% confidence level. This study, therefore, offers some empirical support for Florida's policy positively impacting advantaged students. One limitation of this study is that most grade levels were insignificant for many of the categories, but for the few grade levels that did have strong significance, they contributed to this claim. However, it should be noted that all grade levels, regardless of subject, had disadvantaged students testing significantly lower than their advantaged counterparts. Proportion wise, this resulted in nearly half as many disadvantaged students as advantaged students in all grade levels as being satisfactory learners. For both states, there contained about 2 to 3 times as many disadvantaged schools as advantaged schools, revealing the existence of significant educational disparities in both states. Finally, we would like to mention limitations with the data led most grades to be statistically insignificant for the analysis; however, overall, we hope that this study offers some insight into the effects of the educational policies during the 2020-2021 school year for states that chose distance versus face to face instruction and how disadvantaged and advantaged students were affected by such policies.

7 Future research

This research paper attempts to analyze the impact of widespread in person versus virtual learning along with their impacts on socioeconomically disadvantaged students. We believe there can be further research done on how virtual schools were impacted along with how students truly benefit from in-person versus virtual learning. With more data and refinement, more accurate analysis could be done on the relationship between virtual learning and academic achievement. We also believe future research should focus on other factors such as public funding for schools and how socioeconomic status affects distance learning. Findings connecting virtual learning to possible beneficial education outcomes would not only change how we perceive education but how effective the notion of the traditional classroom truly is.

8 Bibliography

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9 Appendix

9.1 Triple Difference Estimator Equations

Here are the equations for the β values for reference:

$$\beta_0 = E[Y|T = 0, D = 0, Post = 0] \tag{6}$$

$$\beta_1 = E[Y|T = 1, D = 0, Post = 0] - E[Y|T = 0, D = 0, Post = 0] \tag{7}$$

$$\beta_2 = E[Y|T = 0, D = 1, Post = 0] - E[Y|T = 0, D = 0, Post = 0] \tag{8}$$

$$\beta_3 = E[Y|T = 0, D = 0, Post = 1] - E[Y|T = 0, D = 0, Post = 0] \tag{9}$$

$$\begin{aligned}\beta_4 = {} & E[Y|T = 1, D = 1, Post = 0] + E[Y|T = 0, D = 0, Post = 0] \\ & -E[Y|T = 1, D = 0, Post = 0] - E[Y|T = 0, D = 1, Post = 0]\end{aligned} \tag{10}$$

$$\begin{aligned}\beta_5 = {} & E[Y|T = 1, D = 0, Post = 1] + E[Y|T = 0, D = 0, Post = 0] \\ & -E[Y|T = 1, D = 0, Post = 0] - E[Y|T = 0, D = 0, Post = 1]\end{aligned} \tag{11}$$

$$\begin{aligned}\beta_6 = {} & E[Y|T = 0, D = 1, Post = 1] + E[Y|T = 0, D = 0, Post = 0] \\ & -E[Y|T = 0, D = 1, Post = 0] - E[Y|T = 0, D = 0, Post = 1]\end{aligned} \tag{12}$$

$$\begin{aligned}\beta_7 = {} & (E[Y|T = 1, D = 1, Post = 1] - E[Y|T = 1, D = 1, Post = 0]) \\ & -(E[Y|T = 1, D = 0, Post = 1] - E[Y|T = 1, D = 0, Post = 0]) \\ & -(E[Y|T = 0, D = 1, Post = 1] - E[Y|T = 0, D = 1, Post = 0]) \\ & +(E[Y|T = 0, D = 0, Post = 1] - E[Y|T = 0, D = 0, Post = 0])\end{aligned} \tag{13}$$

9.2 Tables

Table 1: Georgia Non-Virtual School Observations by Grade

	Year 1	Year 2	Year 3	Year 4	Year 5
Grade 3	1239	1241	1243	1224	1242
Grade 4	1234	1235	1241	1222	1244
Grade 5	1229	1228	1231	1213	1238
Grade 6	563	571	567	552	581
Grade 7	547	552	554	529	567
Grade 8	552	556	557	532	564

Table 2: Georgia Virtual School Observations by Grade

	Year 1	Year 2	Year 3	Year 4	Year 5
Grade 3	2	2	1	3	3
Grade 4	2	2	2	4	5
Grade 5	3	3	2	5	6
Grade 6	3	3	3	6	7
Grade 7	3	3	3	6	7
Grade 8	4	3	4	5	7

Table 3: Florida Non-virtual School Observations by Grade

	Year 1	Year 2	Year 3	Year 4	Year 5
Grade 3	2145	2160	2178	2196	2208
Grade 4	2120	2146	2165	2199	2188
Grade 5	2125	2142	2165	2194	2196
Grade 6	1081	1109	1138	1151	1166
Grade 7	1010	1038	1066	1076	1120
Grade 8	1003	1033	1069	1084	1114

Table 4: Florida Virtual School Observations by Grade

	Year 1	Year 2	Year 3	Year 4	Year 5
Grade 3	8	6	7	38	33
Grade 4	7	9	8	38	35
Grade 5	9	10	13	39	36
Grade 6	16	17	16	38	40
Grade 7	20	20	22	42	42
Grade 8	25	21	23	45	42

Table 5: Non-virtual English

Grade	β_0	β_1	β_2	β_3	R^2
3	37.0276 (1.032) [0.000]	19.3342 (1.459) [0.000]	-4.1182 (1.631) [0.045]	-0.3987 (2.307) [0.868]	0.981
4	39.8572 (1.045) [0.000]	14.7515 (1.478) [0.000]	-6.0795 (1.652) [0.010]	3.9368 (2.337) [0.143]	0.973
5	39.8399 (1.477) [0.000]	12.4063 (2.088) [0.001]	-2.8884 (2.335) [0.262]	2.6750 (3.302) [0.449]	0.922
6	38.8158 (1.408) [0.000]	13.0123 (1.992) [0.001]	-2.0820 (2.227) [0.386]	2.1025 (3.149) [0.529]	0.931
7	34.3825 (0.800) [0.000]	15.2404 (1.132) [0.000]	-0.4855 (1.265) [0.714]	-2.5919 (1.789) [0.198]	0.978
8	40.1502 (1.096) [0.000]	13.3766 (1.550) [0.000]	-2.7575 (1.733) [0.163]	-2.2590 (2.451) [0.392]	0.952

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

For all grades, β_0 and β_1 are statistically significant, which basically means non-virtual students in the control group, Georgia, on average contain about 37 to 40 percent of satisfactory learners for English; this also indicates that non-virtual students in the treatment group, Florida, on average contained about 13 to 19 percent more satisfactory learners than the control group for English as we expect due to achievement levels. For β_3 however, all grades were insignificant, and for β_2, nearly all grades were insignificant except for grades 3 and 4, which both had negative values. This means the percentage of satisfactory learners in Georgia went down for grades 3 and 4 by 4 and 6 percent respectively in the post period.

Table 6: Virtual English

Grade	β_0	β_1	β_2	β_3	R^2
3	30.8500 (5.467) [0.001]	34.5250 (7.731) [0.004]	6.5667 (8.644) [0.476]	-12.7096 (12.224) [0.339]	0.808
4	45.0167 (5.358) [0.000]	19.6685 (7.577) [0.041]	2.3083 (8.472) [0.794]	-7.1462 (11.981) [0.573]	0.589
5	50.4222 (5.397) [0.000]	10.1254 (7.633) [0.233]	-2.9289 (8.534) [0.743]	4.5693 (12.068) [0.718]	0.414
6	53.5667 (2.872) [0.000]	11.6429 (4.062) [0.029]	-12.6929 (4.541) [0.031]	14.8366 (6.423) [0.060]	0.867
7	48.2111 (1.480) [0.000]	17.9813 (2.093) [0.000]	-11.2837 (2.340) [0.003]	8.2699 (3.309) [0.047]	0.970
8	59.1250 (3.491) [0.000]	13.1566 (4.937) [0.037]	-13.1407 (5.520) [0.055]	4.9742 (7.806) [0.548]	0.797

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

For all grades, β_0 and β_1 are statistically significant except for grade 5's β_1, meaning virtual students in the control group, Georgia, on average contain about 30 to 59 percent of satisfactory learners for English; this also indicates that virtual students in the treatment group, Florida, on average contained about 13 to 35 percent more satisfactory learners than the control group for English as we expect due to achievement levels. In this category, only grades 6 and 7 have significant β_2 and β_3 values. For grades 6 and 7, this means that Georgia virtual students decreased by about 13 and 11 percentage points respectively in the post period. Additionally, for grades 6 and 7, Florida increased by about 15 and 8 percentages points respectively more than it would have without the policy. This reveals evidence that Florida's in-person instruction improved learning outcomes for virtual schools compared to Georgia.

Table 7: Non-virtual math

Grade	β_0	β_1	β_2	β_3	R^2
3	44.8958	15.9234	-8.1365	0.4179	0.899
	(2.237)	(3.164)	(3.538)	(5.003)	
	[0.000]	[0.002]	[0.061]	[0.936]	
4	44.7450	16.5807	-5.7627	-0.5240	0.936
	(1.696)	(2.398)	(2.681)	(3.792)	
	[0.000]	[0.000]	[0.075]	[0.895]	
5	36.7061	20.2728	-5.1944	-2.2856	0.974
	(1.230)	(1.739)	(1.945)	(2.750)	
	[0.000]	[0.000]	[0.037]	[0.438]	
6	34.9167	17.9037	-8.8440	5.1961	0.979
	(1.141)	(1.613)	(1.804)	(2.551)	
	[0.000]	[0.000]	[0.003]	[0.088]	
7	38.5271	12.3276	-7.3860	-0.1643	0.987
	(0.611)	(0.864)	(0.966)	(1.366)	
	[0.000]	[0.000]	[0.000]	[0.908]	
8	32.1632	10.4589	-2.6194	-3.4476	0.878
	(1.414)	(2.000)	(2.236)	(3.162)	
	[0.000]	[0.002]	[0.286]	[0.317]	

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

For the non-virtual math category, β_0 and β_1 were significant for all grades following similar patterns to the English non-virtual category. However, for β_2, we observe that all grades except grade 8 are statistically significant. All β_2 values are negative which means that Georgian students dropped in the percentage of satisfactory learners in the post period. For β_3, all values are insignificant.

Table 8: Virtual math

Grade	β_0	β_1	β_2	β_3	R^2
3	28.7000 (6.113) [0.003]	15.5407 (8.645) [0.122]	1.5833 (9.666) [0.875]	-10.0641 (13.670) [0.489]	0.385
4	34.9833 (4.924) [0.000]	13.8685 (6.963) [0.093]	-4.9533 (7.785) [0.548]	-4.1479 (11.010) [0.719]	0.535
5	26.4556 (3.439) [0.000]	11.0778 (4.863) [0.063]	1.3378 (5.437) [0.814]	-5.5025 (7.689) [0.501]	0.508
6	32.9778 (3.045) [0.000]	21.8279 (4.306) [0.002]	-12.7092 (4.814) [0.039]	6.8182 (6.808) [0.355]	0.913
7	41.6222 (2.560) [0.000]	21.4468 (3.620) [0.001]	-11.0520 (4.047) [0.034]	3.2146 (5.723) [0.595]	0.928
8	32.3056 (2.639) [0.000]	18.3981 (3.732) [0.003]	-6.7613 (4.172) [0.156]	1.0454 (5.901) [0.865]	0.887

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

All β_0 values are statistically significant but only grades 6, 7, and 8 are significant for β_1. Again, these values follow similar logic to the tables above. For β_2, only grades 6 and 7 are statistically significant. These coefficient are both negative, which reveals that Georgian virtual students decreased in performance in the post period for math. For β_3, none of the values are significant.

Table 9: English DDD

Grade	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	R^2
3	56.6495	17.1661	-4.5535	-27.2711	-0.9180	2.3318	-1.4721	1.5417	0.992
	(1.099)	(1.555)	(1.738)	(1.555)	(2.458)	(2.199)	(2.458)	(3.477)	
	[0.000]	[0.000]	[0.022]	[0.000]	[0.715]	[0.310]	[0.560]	[0.665]	
4	60.3849	9.6522	-7.5765	-28.4909	6.2107	6.4605	0.0175	-2.3688	0.993
	(0.945)	(1.336)	(1.494)	(1.336)	(2.112)	(1.889)	(2.112)	(2.987)	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.012]	[0.005]	[0.994]	[0.443]	
5	60.5984	8.0295	-4.8253	-28.7932	4.8069	5.4500	0.5669	-2.1331	0.983
	(1.432)	(2.024)	(2.263)	(2.024)	(3.201)	(2.863)	(3.201)	(4.527)	
	[0.000]	[0.002]	[0.054]	[0.000]	[0.159]	[0.081]	[0.862]	[0.646]	
6	57.2720	9.0914	-4.4448	-25.7973	3.0321	2.6573	0.9617	0.0630	0.979
	(1.470)	(2.079)	(2.325)	(2.079)	(3.288)	(2.940)	(3.288)	(4.649)	
	[0.000]	[0.001]	[0.080]	[0.000]	[0.375]	[0.384]	[0.775]	[0.989]	
7	52.4912	12.6978	-2.9399	-25.3030	-1.6951	0.6372	1.0088	0.4136	0.993
	(0.857)	(1.212)	(1.355)	(1.212)	(1.916)	(1.713)	(1.916)	(2.709)	
	[0.000]	[0.000]	[0.051]	[0.000]	[0.394]	[0.716]	[0.608]	[0.881]	
8	58.8627	10.6402	-5.8697	-25.9847	-1.1502	0.9924	1.7377	0.4355	0.988
	(1.152)	(1.629)	(1.822)	(1.629)	(2.576)	(2.304)	(2.576)	(3.644)	
	[0.000]	[0.000]	[0.007]	[0.000]	[0.663]	[0.674]	[0.513]	[0.907]	

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

All grades are significant for β_0, β_1, β_2, and β_3. For Georgia's advantaged pre period, students averaged around 58 to 56 percentage points of satisfactory learners. For advantaged students in the pre period, we observe that Florida averaged about 10 to 17 percentage points higher between grades. For Georgia's disadvantaged students in the pre period, we see that these students averaged about 3 to 6 percentage points less than their advantaged peers. For Georgia's advantaged students in the pre period, we observe significant drops in performance to the post period with around 25 to 27 percentage points. For β_4, only grade 4 is statistically significant with a positive 6 percentage point increase which means in the pre period, Georgia's disparity between disadvantaged and advantaged students was greater than Florida's by 6 percentage points. For β_5, only grade 4 is significant with a positive 6 percentage point increase. For the advantaged group in the treatment, satisfactory learners increased by 6 percentage points due to the existence of the policy. No grades are significant for β_6 and β_7.

Table 10: Math DDD

Grade	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	R^2
3	63.8142	10.5423	-7.1531	-26.2912	1.1204	6.9478	-3.5239	-0.0793	0.962
	(2.188)	(3.094)	(3.459)	(3.094)	(4.892)	(4.376)	(4.892)	(6.919)	
	[0.000]	[0.005]	[0.061]	[0.000]	[0.823]	[0.138]	[0.485]	[0.991]	
4	65.5251	9.0390	-6.0010	-28.8437	1.7388	9.9533	-1.8913	-2.2004	0.980
	(1.610)	(2.277)	(2.546)	(2.277)	(3.601)	(3.221)	(3.601)	(5.092)	
	[0.000]	[0.002]	[0.036]	[0.000]	[0.638]	[0.009]	[0.609]	[0.673]	
5	56.9432	14.5495	-5.8444	-28.0708	-0.7654	7.4029	-1.3198	-1.1604	0.990
	(1.204)	(1.703)	(1.904)	(1.703)	(2.692)	(2.408)	(2.692)	(3.808)	
	[0.000]	[0.000]	[0.010]	[0.000]	[0.781]	[0.010]	[0.633]	[0.766]	
6	53.3135	13.9618	-12.0074	-25.7191	7.6471	2.5475	2.1725	-2.3822	0.992
	(1.044)	(1.477)	(1.651)	(1.477)	(2.335)	(2.088)	(2.335)	(3.302)	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.007]	[0.246]	[0.370]	[0.484]	
7	58.4235	8.1896	-10.4429	-27.7989	1.9699	2.8967	1.6621	-1.3054	0.998
	(0.479)	(0.678)	(0.758)	(0.678)	(1.071)	(0.958)	(1.071)	(1.515)	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.091]	[0.011]	[0.147]	[0.406]	
8	46.4098	10.8983	-1.0538	-19.8352	-5.9487	-2.7497	-4.7590	5.2031	0.975
	(1.438)	(2.034)	(2.274)	(2.034)	(3.215)	(2.876)	(3.215)	(4.547)	
	[0.000]	[0.000]	[0.651]	[0.000]	[0.089]	[0.358]	[0.165]	[0.275]	

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

All grades are significant for β_0 and β_1, and they follow similar patterns to Table 5. For β_2, all grades except 3 and 8 are statistically significant. These grades follow a similar pattern to Table 5. For β_3, all values are statistically significant and follow a similar pattern to Table 5. For β_4, only grade 6 is statistically significant around a positive 8 percentage point increase meaning Georgia's disparity in the pre period was about 8 percentage points greater than Florida's. β_5 contains significant values for grades 4, 5, and 7 at 10, 7, and 3 positive percentage points respectively. This means the proportion of satisfactory learners in Florida increased due to the treatment. No grades are significant for β_6 and β_7.

Table 11: English Disadvantaged DiD

Grade	β_0	β_1	β_2	β_3	R^2
3	29.3784 (0.947) [0.000]	19.4979 (1.340) [0.000]	-6.0257 (1.498) [0.007]	0.6237 (2.118) [0.778]	0.985
4	31.8940 (1.180) [0.000]	16.1127 (1.669) [0.000]	-7.5590 (1.866) [0.007]	3.8419 (2.639) [0.196]	0.972
5	31.8052 (1.440) [0.000]	13.4795 (2.036) [0.001]	-4.2583 (2.276) [0.111]	2.6738 (3.219) [0.438]	0.937
6	31.4747 (1.297) [0.000]	11.7488 (1.834) [0.001]	-3.4830 (2.051) [0.140]	3.0950 (2.900) [0.327]	0.935
7	27.1882 (0.700) [0.000]	13.3350 (0.991) [0.000]	-1.9311 (1.108) [0.132]	-1.2815 (1.566) [0.445]	0.980
8	32.8780 (1.106) [0.000]	11.6326 (1.564) [0.000]	-4.1321 (1.749) [0.056]	-0.7147 (2.474) [0.782]	0.944

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

For β_0 and β_1, all values are statistically significant. For β_0, Georgia advantaged students averaged 27 to 33 percent in the pre period between grades. For β_1, we observe that Florida had increases of about 12 to 19 percentage points between grades compared to Georgia. For β_3, only grades 3 and 4 were statistically significant. These were all negative values, meaning Georgia disadvantaged students tested worse after the policy period. For β_3, none of the grades were significant.

Table 12: English Advantaged DiD

Grade	β_0	β_1	β_2	β_3	R^2
3	56.6495 (1.233) [0.000]	17.1661 (1.744) [0.000]	-4.5535 (1.949) [0.058]	-0.9180 (2.757) [0.750]	0.966
4	60.3849 (0.626) [0.000]	9.6522 (0.886) [0.000]	-7.5765 (0.990) [0.000]	6.2107 (1.400) [0.004]	0.984
5	60.5984 (1.423) [0.000]	8.0295 (2.013) [0.007]	-4.8253 (2.251) [0.076]	4.8069 (3.183) [0.182]	0.883
6	57.2720 (1.625) [0.000]	9.0914 (2.298) [0.007]	-4.4448 (2.569) [0.134]	3.0321 (3.634) [0.436]	0.860
7	52.4912 (0.989) [0.000]	12.6978 (1.398) [0.000]	-2.9399 (1.563) [0.109]	-1.6951 (2.211) [0.472]	0.958
8	58.8627 (1.196) [0.000]	10.6402 (1.692) [0.001]	-5.8697 (1.892) [0.021]	-1.1502 (2.675) [0.682]	0.933

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

For β_0 and β_1, all grades are significant, and they all follow a similar pattern to Table 7; however, it should be noted that the Advantaged scores are significantly higher compared to the disadvantaged counterparts, nearly double for all grades. For β_2, only grades 4 and 8 were statistically significant. These negative values represent a decrease in satisfactory learners in the post period for Georgia. For β_3, only grade 4 is significant with a positive 6 percentage point change. This means that Florida's advantaged students scored better due to the implementation of the policy.

Table 13: Math Disadvantaged DiD

Grade	β_0	β_1	β_2	β_3	R^2
3	37.5229 (2.261) [0.000]	17.4901 (3.197) [0.002]	-10.6770 (3.575) [0.024]	1.0411 (5.055) [0.844]	0.919
4	36.6814 (1.841) [0.000]	18.9923 (2.603) [0.000]	-7.8923 (2.910) [0.035]	-0.4616 (4.116) [0.914]	0.945
5	28.8724 (1.251) [0.000]	21.9524 (1.769) [0.000]	-7.1642 (1.977) [0.011]	-1.9258 (2.796) [0.517]	0.979
6	27.5944 (1.084) [0.000]	16.5093 (1.533) [0.000]	-9.8348 (1.714) [0.001]	5.2650 (2.424) [0.073]	0.979
7	30.6246 (0.549) [0.000]	11.0862 (0.777) [0.000]	-8.7808 (0.868) [0.000]	0.6644 (1.228) [0.608]	0.989
8	26.5746 (1.372) [0.000]	8.1486 (1.940) [0.006]	-5.8127 (2.169) [0.037]	-0.7457 (3.068) [0.816]	0.879

Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

For β_0 and β_1, all values are statistically significant. For β_0, Georgia advantaged students averaged 27 to 38 percent in the pre period between grades. For β_1, we observe that Florida had increases of about 8 to 22 percentage points between grades compared to Georgia. For β_2, all grades are significant as well. This means that all grades in Georgia lowered in the post period. For β_3, none of the grades were significant.

Table 14: Math Advantaged DiD

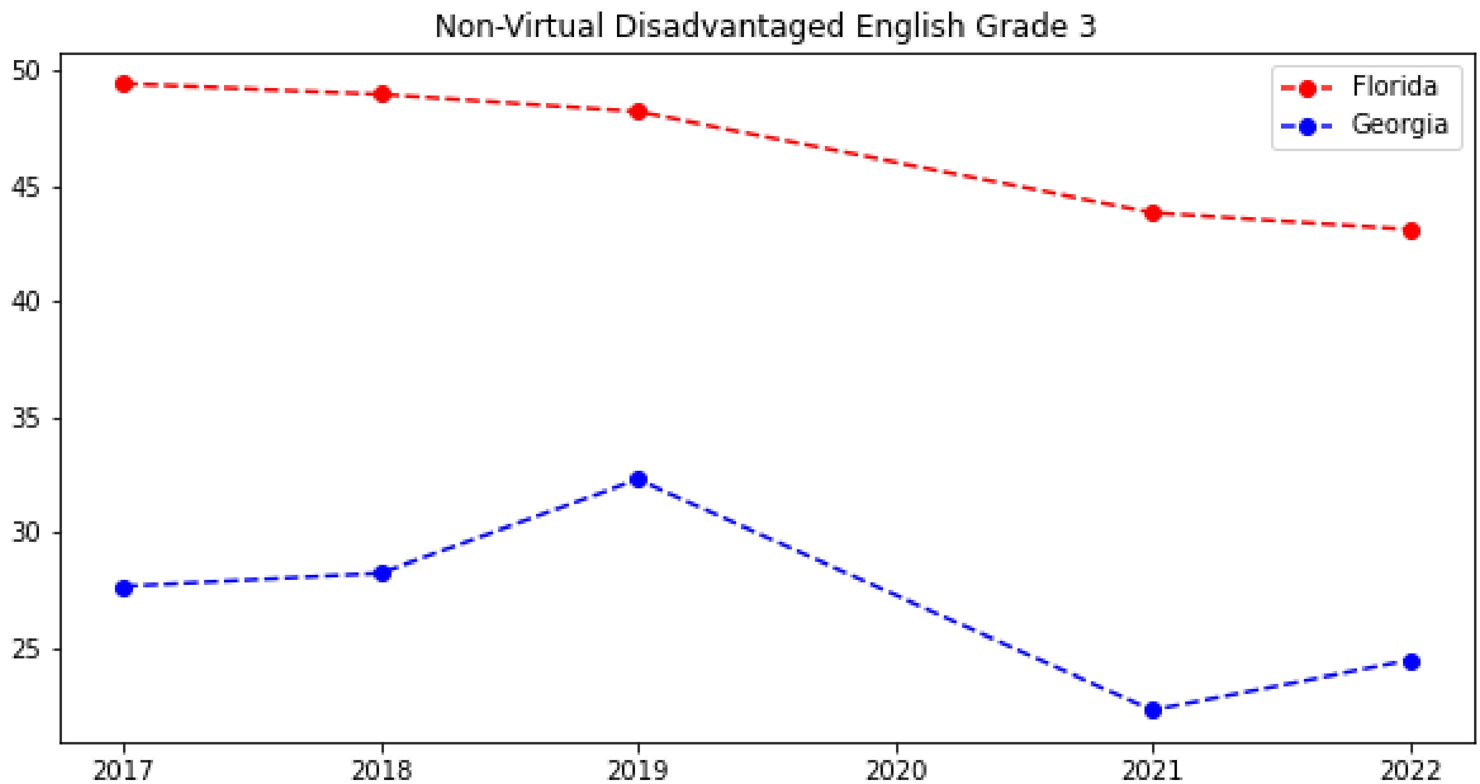
Grade	β_0	β_1	β_2	β_3	R^2
3	63.8142 (2.112) [0.000]	10.5423 (2.987) [0.012]	-7.1531 (3.340) [0.076]	1.1204 (4.723) [0.820]	0.835
4	65.5251 (1.341) [0.000]	9.0390 (1.896) [0.003]	-6.0010 (2.120) [0.030]	1.7388 (2.999) [0.583]	0.903
5	56.9432 (1.156) [0.000]	14.5495 (1.634) [0.000]	-5.8444 (1.827) [0.019]	-0.7654 (2.584) [0.777]	0.962
6	53.3135 (1.003) [0.000]	13.9618 (1.418) [0.000]	-12.0074 (1.585) [0.000]	7.6471 (2.242) [0.014]	0.981
7	58.4235 (0.397) [0.000]	8.1896 (0.562) [0.000]	-10.4429 (0.628) [0.000]	1.9699 (0.888) [0.068]	0.993
8	46.4098 (1.501) [0.000]	10.8983 (2.123) [0.002]	-1.0538 (2.373) [0.673]	-5.9487 (3.356) [0.127]	0.856

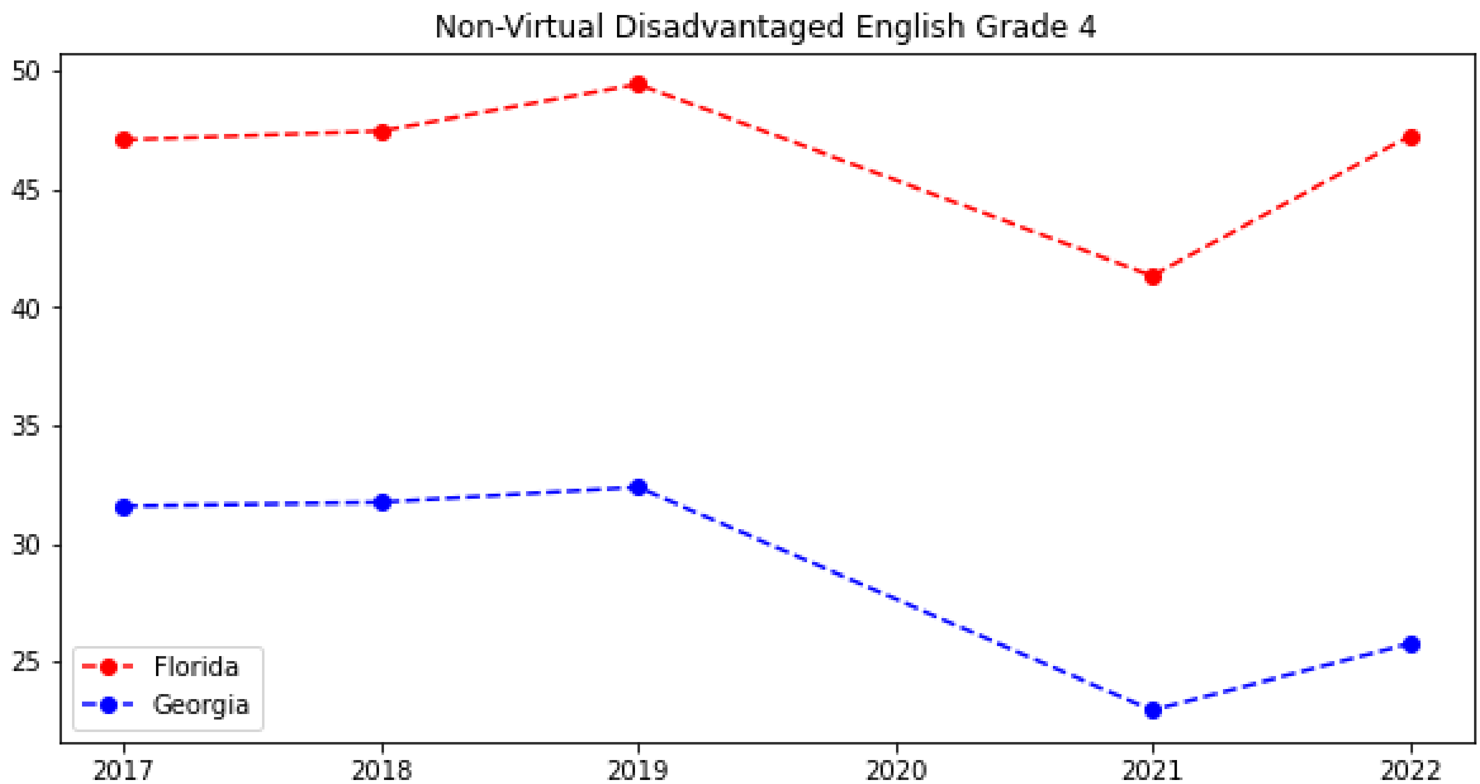
Note: Standard errors denoted in parenthesis and p-values denoted in brackets below each corresponding grade.

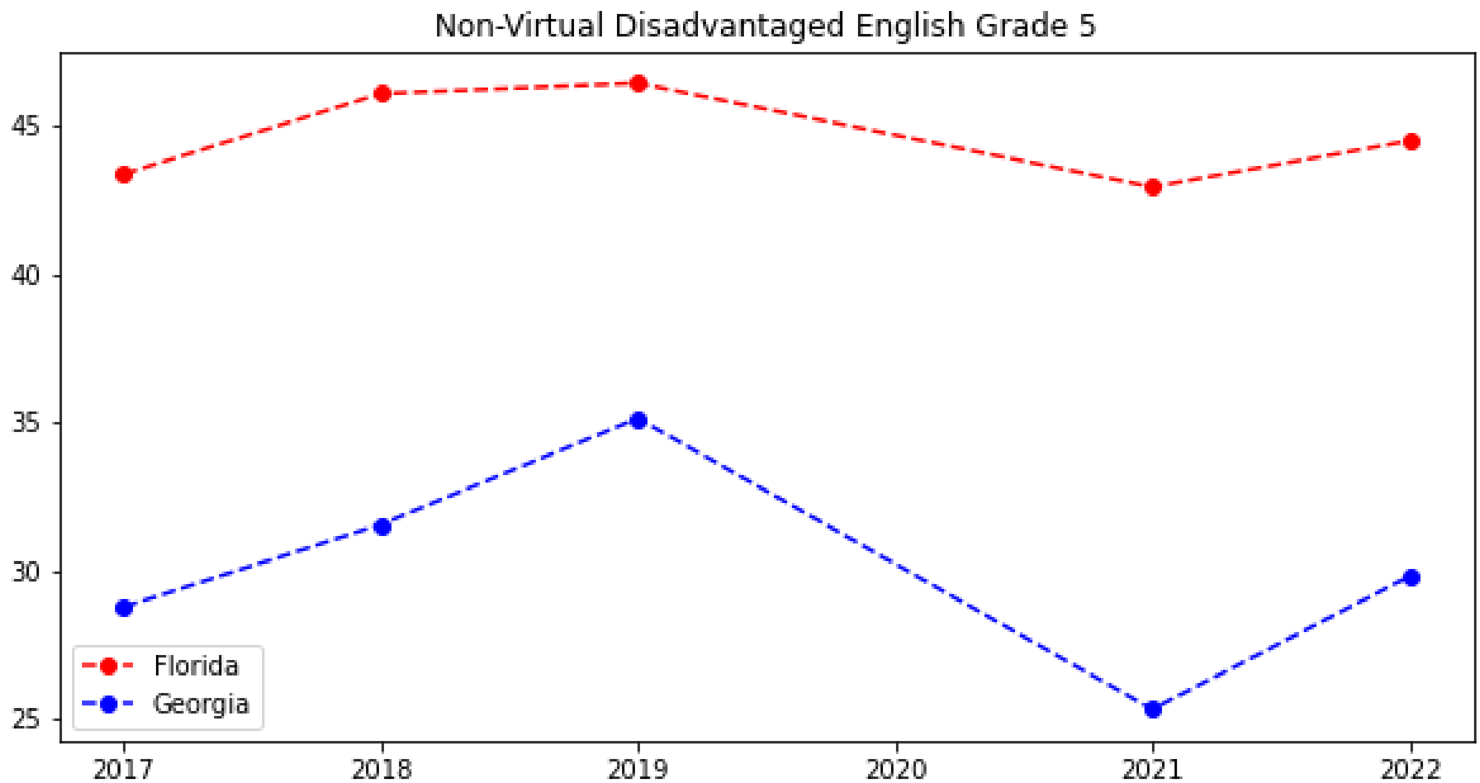
For β_0 and β_1, all grades are significant, and they all follow a similar pattern to Table 7; however, it should be noted that the Advantaged scores are significantly higher compared to the disadvantaged counterparts, nearly double for all grades. For β_2, all grades except 8 are significant. This means Georgia saw a decrease in performance in the post period. For β_3, only grade 6 was significant. This means that grade 6 saw an increase of about 8 percentage points more with the implementation of the policy.

9.3 English Graphs

9.3.1 Non-virtual disadvantaged



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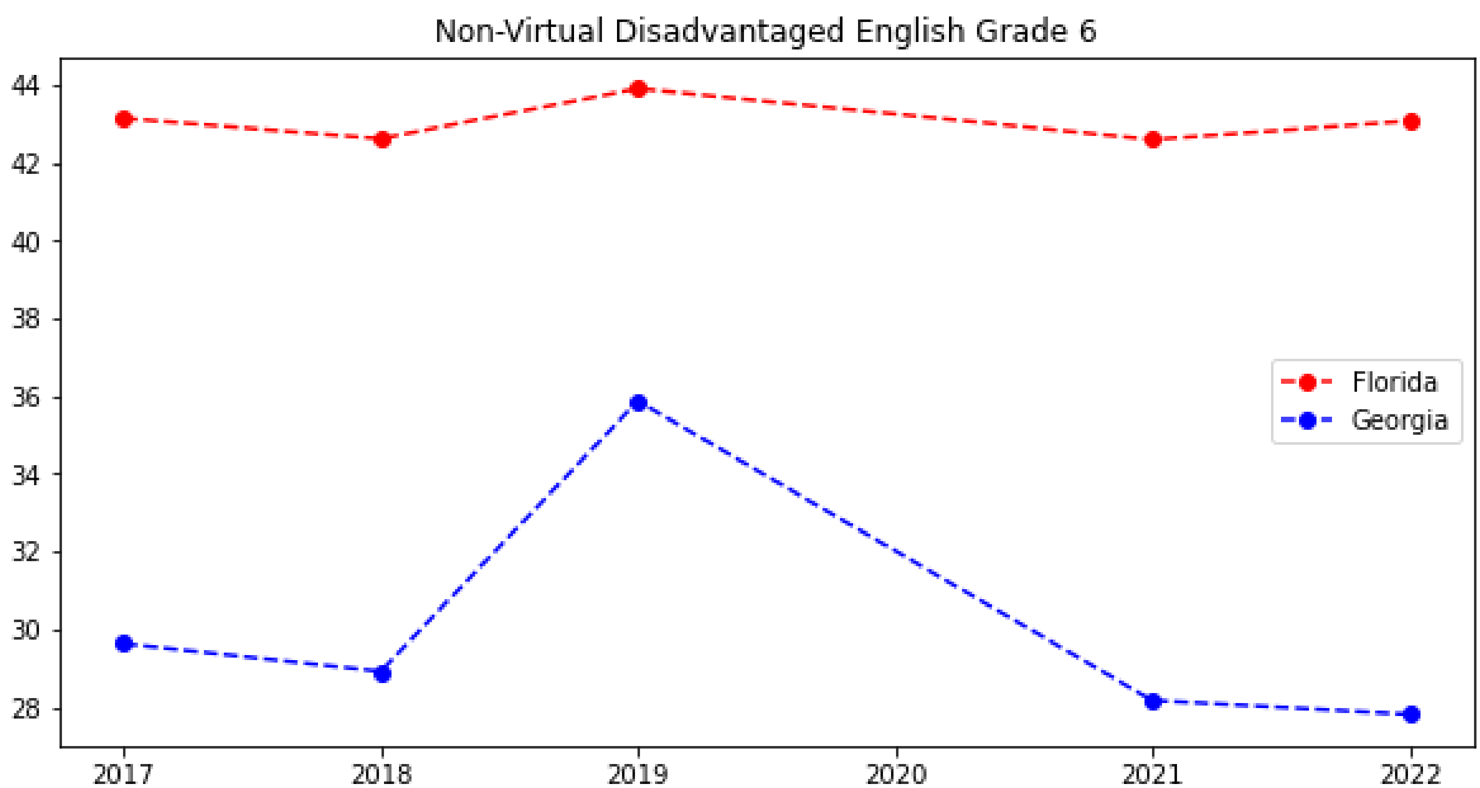
35
30
25
2017
2018
2019
2020
2021
2022
Florida
Georgia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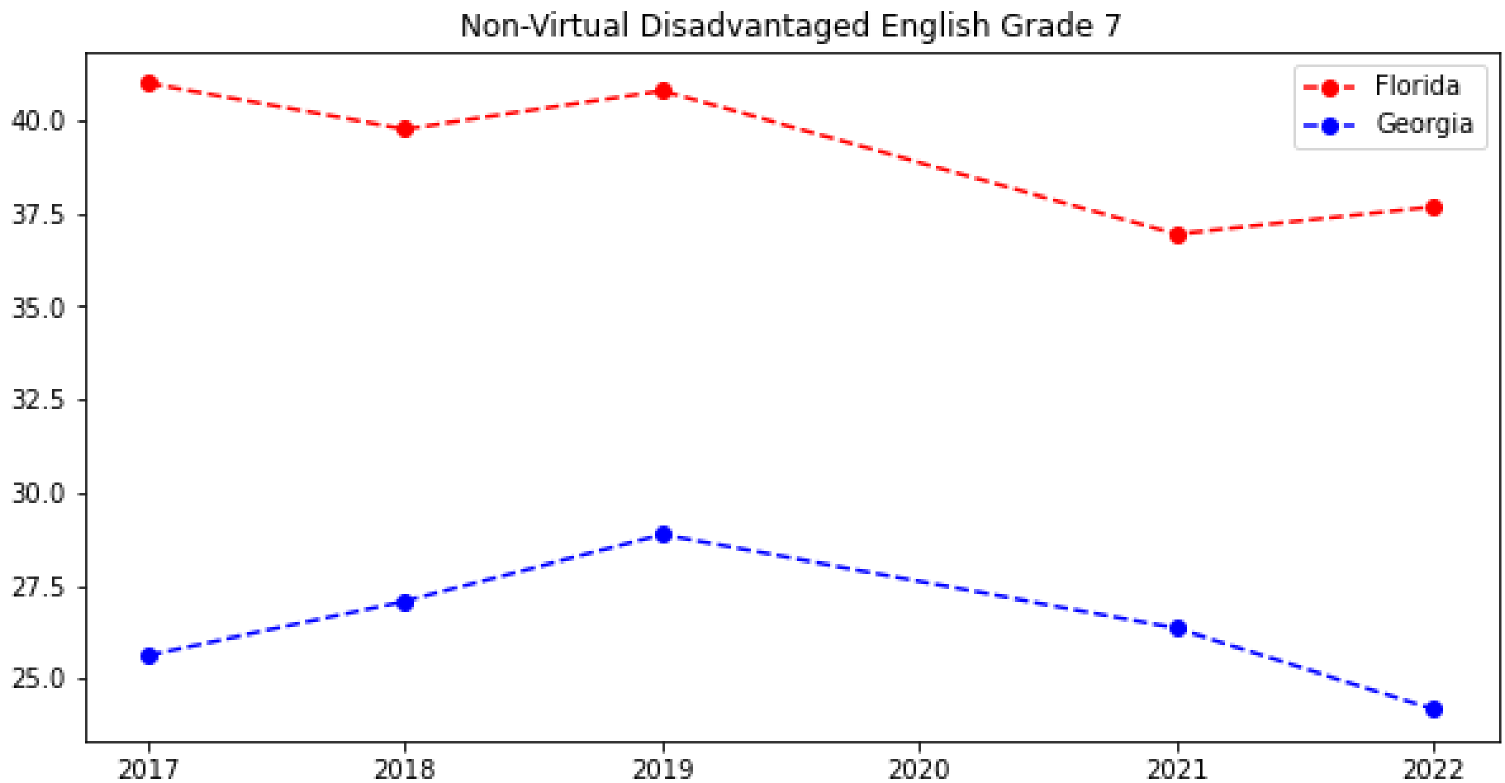
36
34
32
30
28
2017
2018
2019
2020
2021
2022
Florida
Georgia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Georgia
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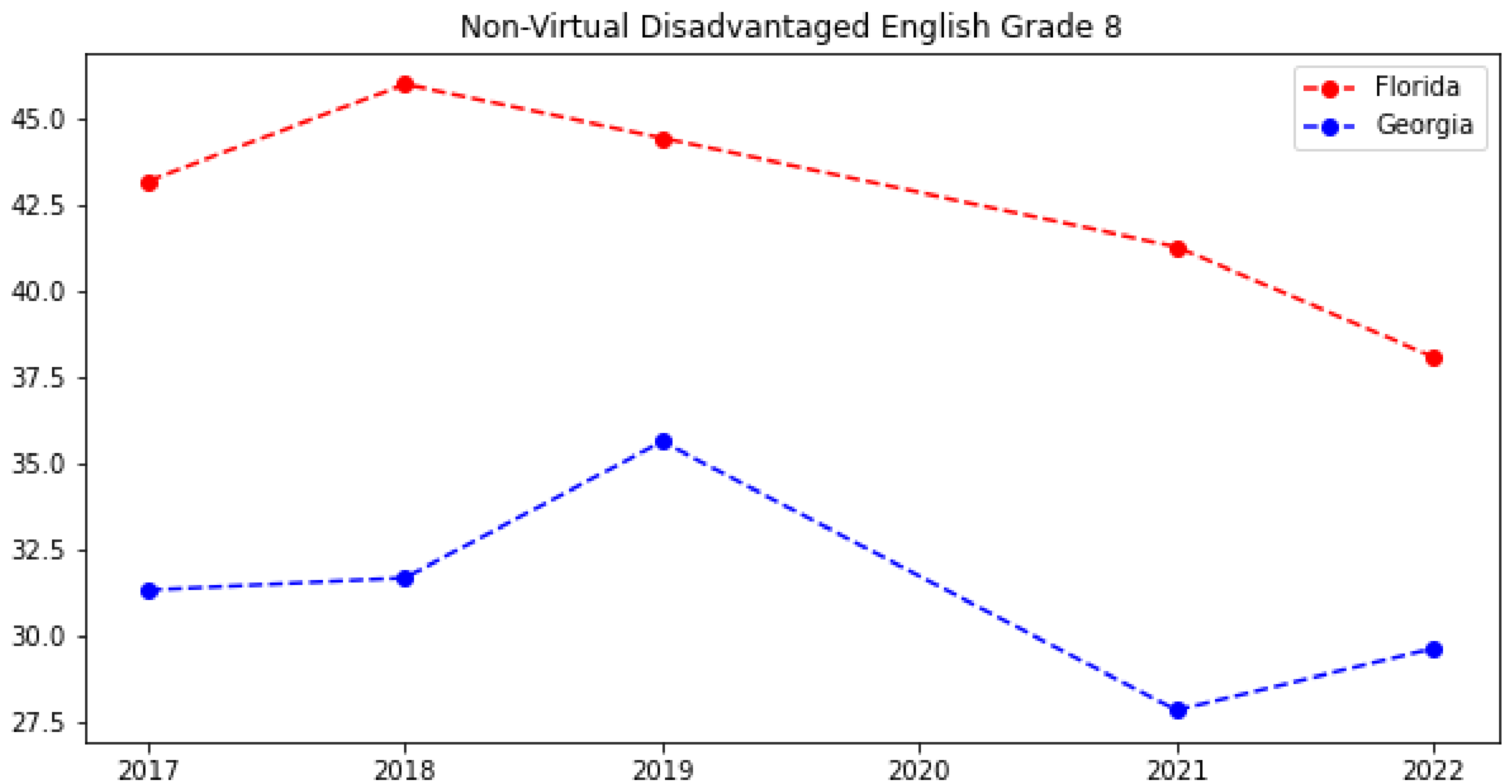
25.0
2017
2018
2019
2020
2021
2022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Georgia
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42.5
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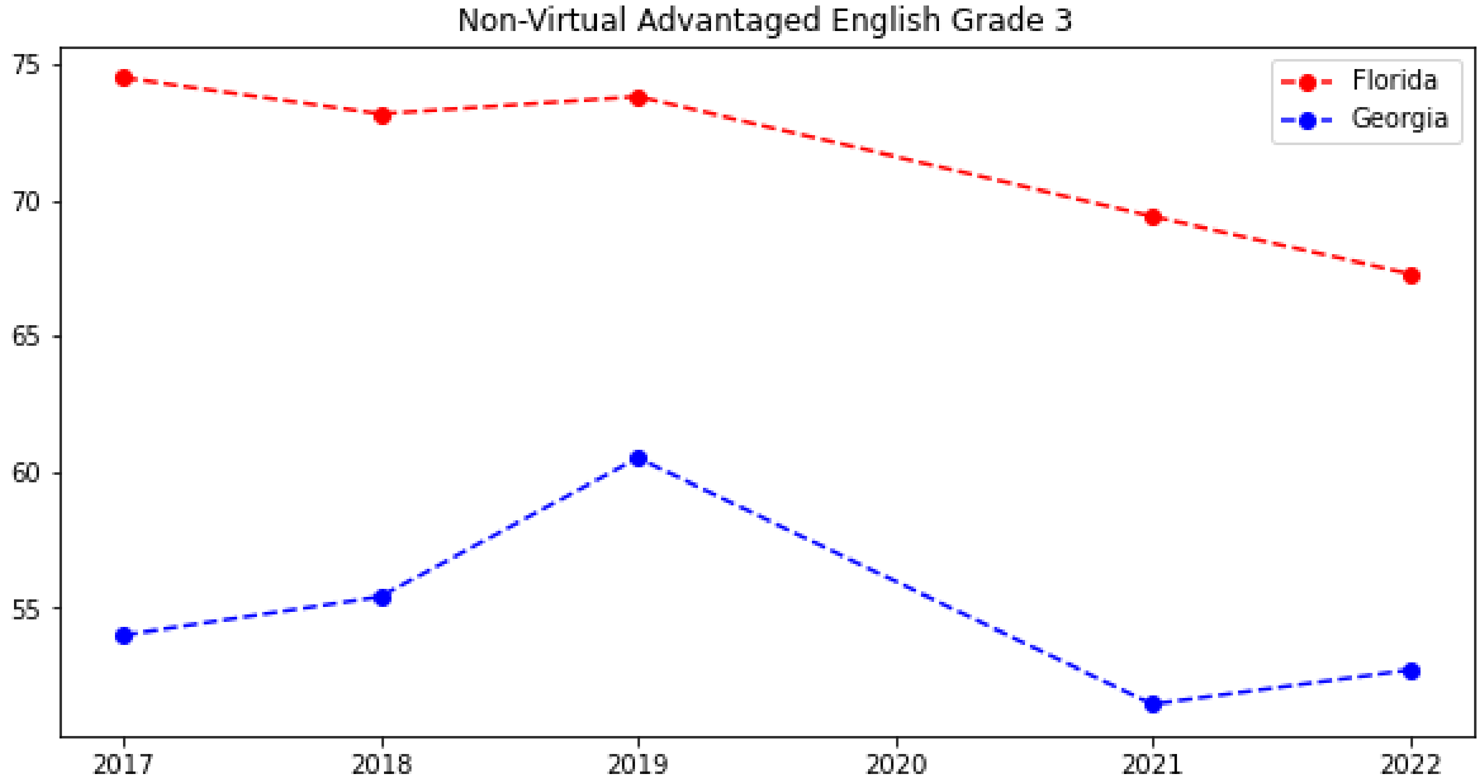
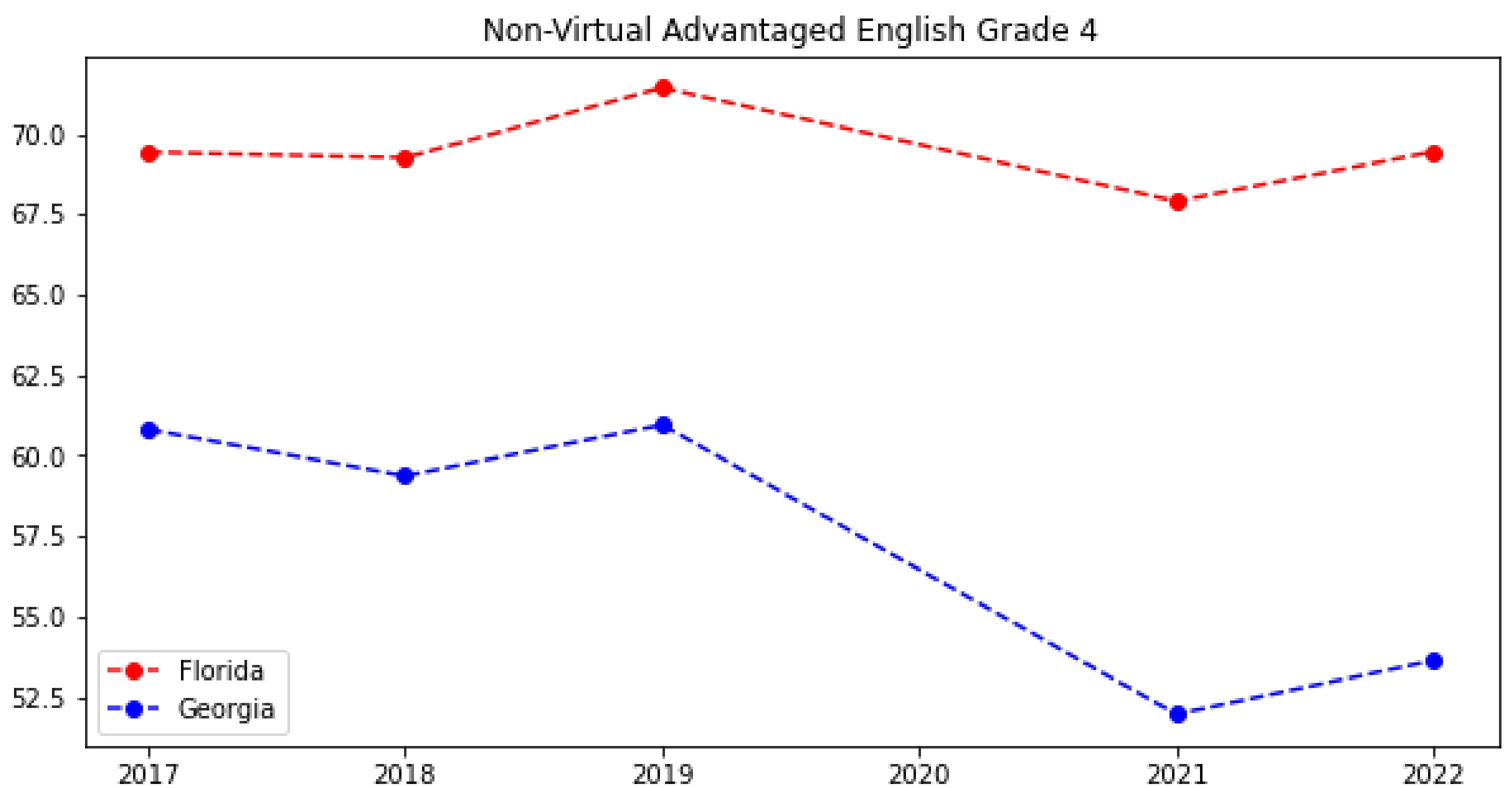
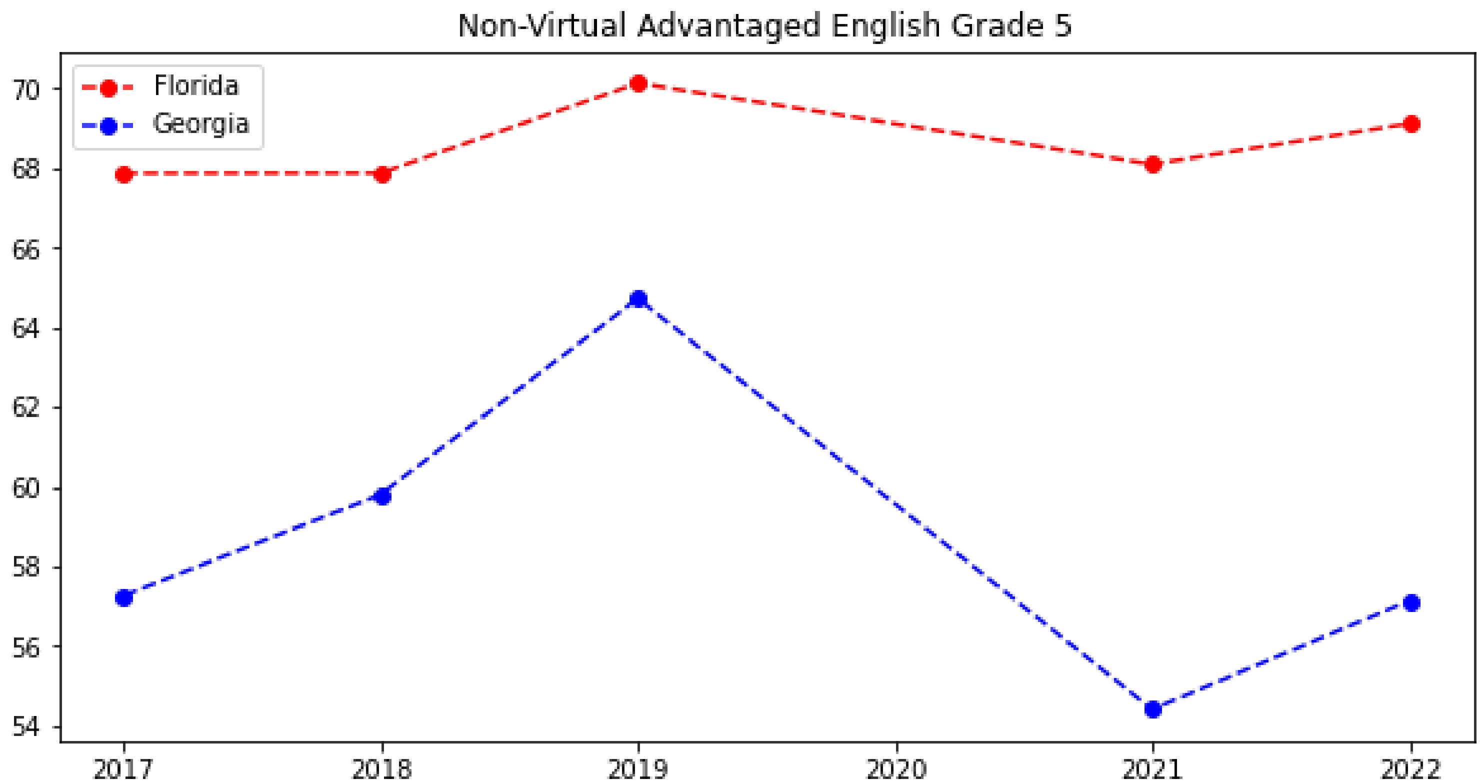
32.5
30.0
27.5
2017
2018
2019
2020
2021
2022

9.3.2 Non-virtual advantaged



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54
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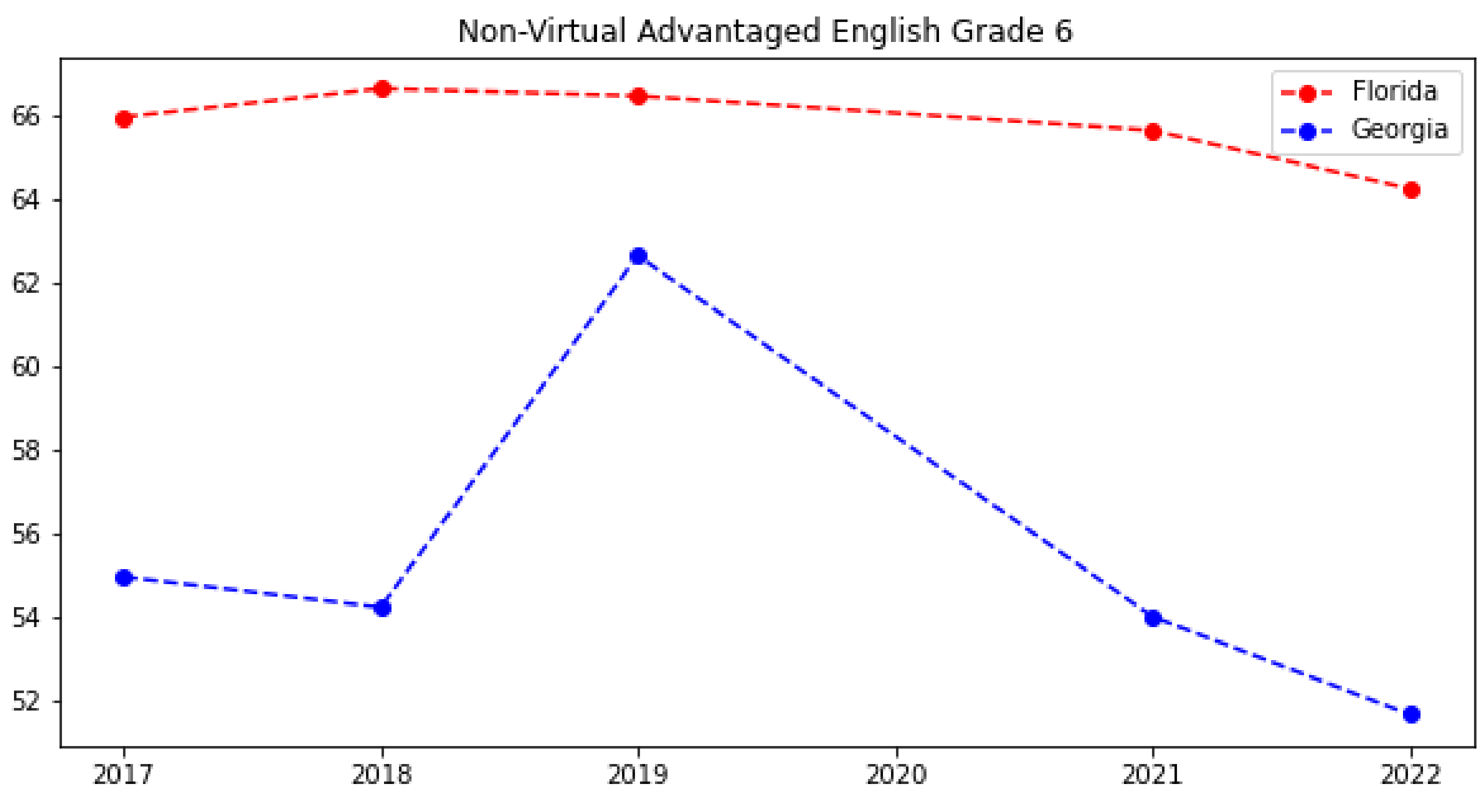
2019
2020
2021
2022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Georgia
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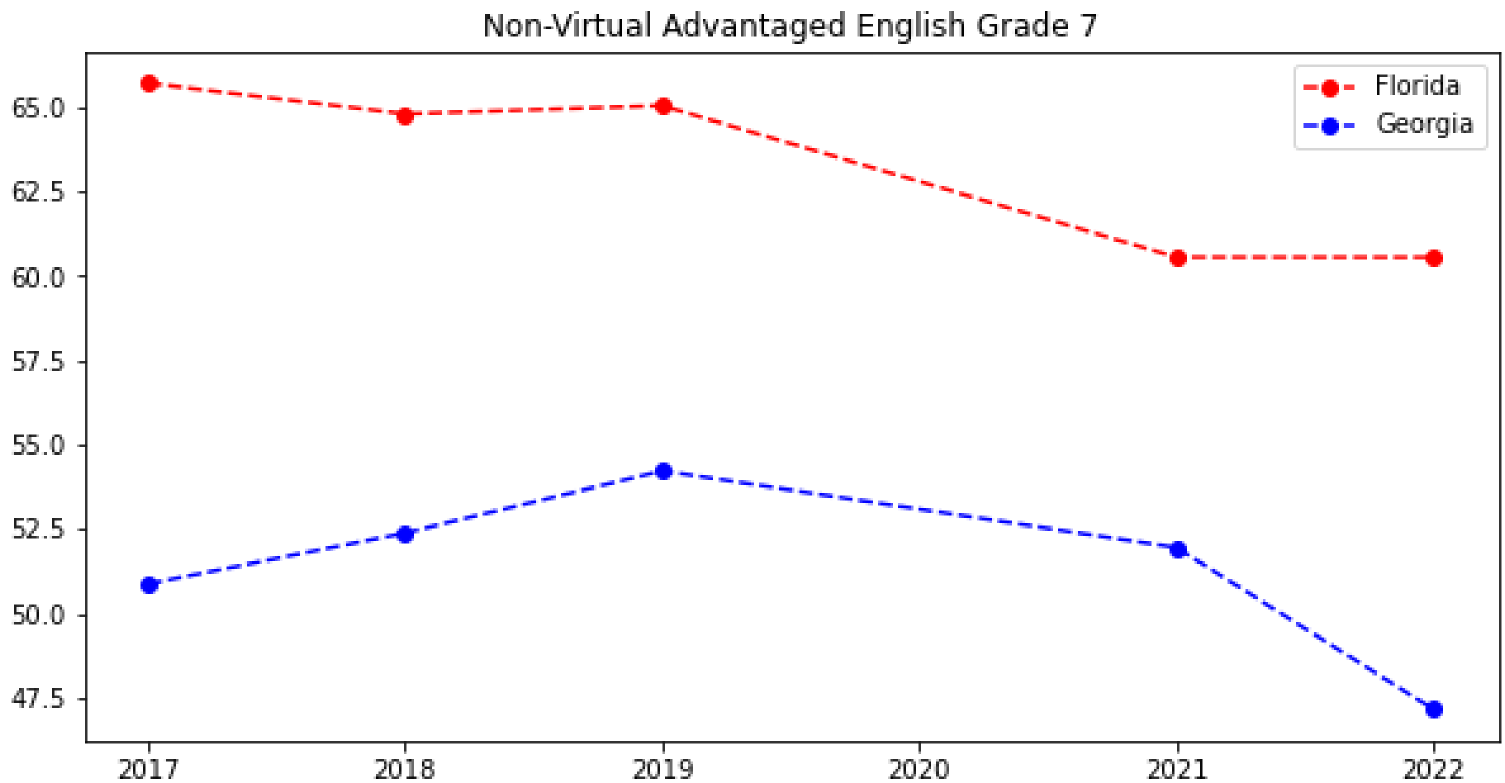
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Georgia
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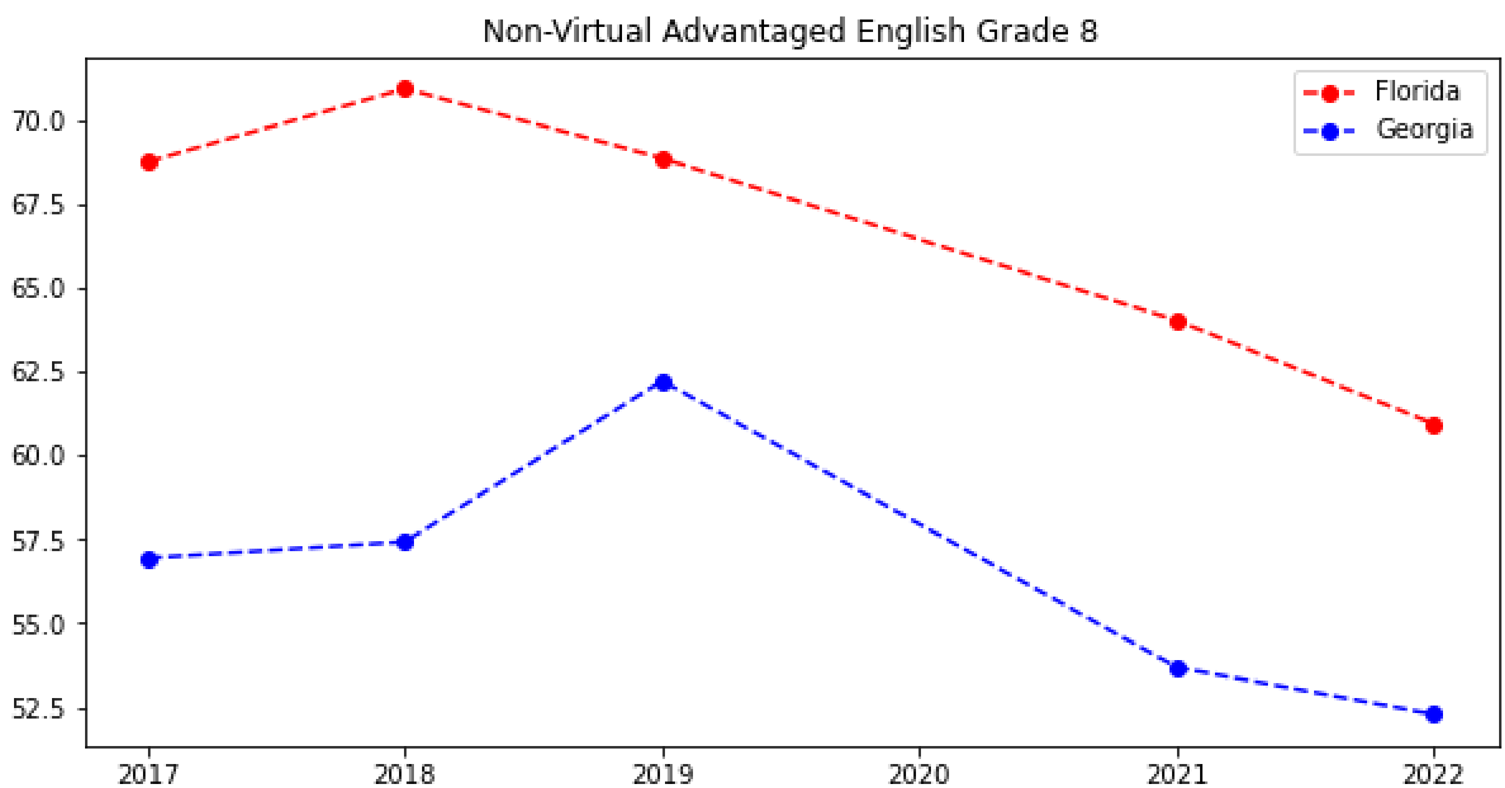
2018
2019
2020
2021
2022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Georgia
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57.5
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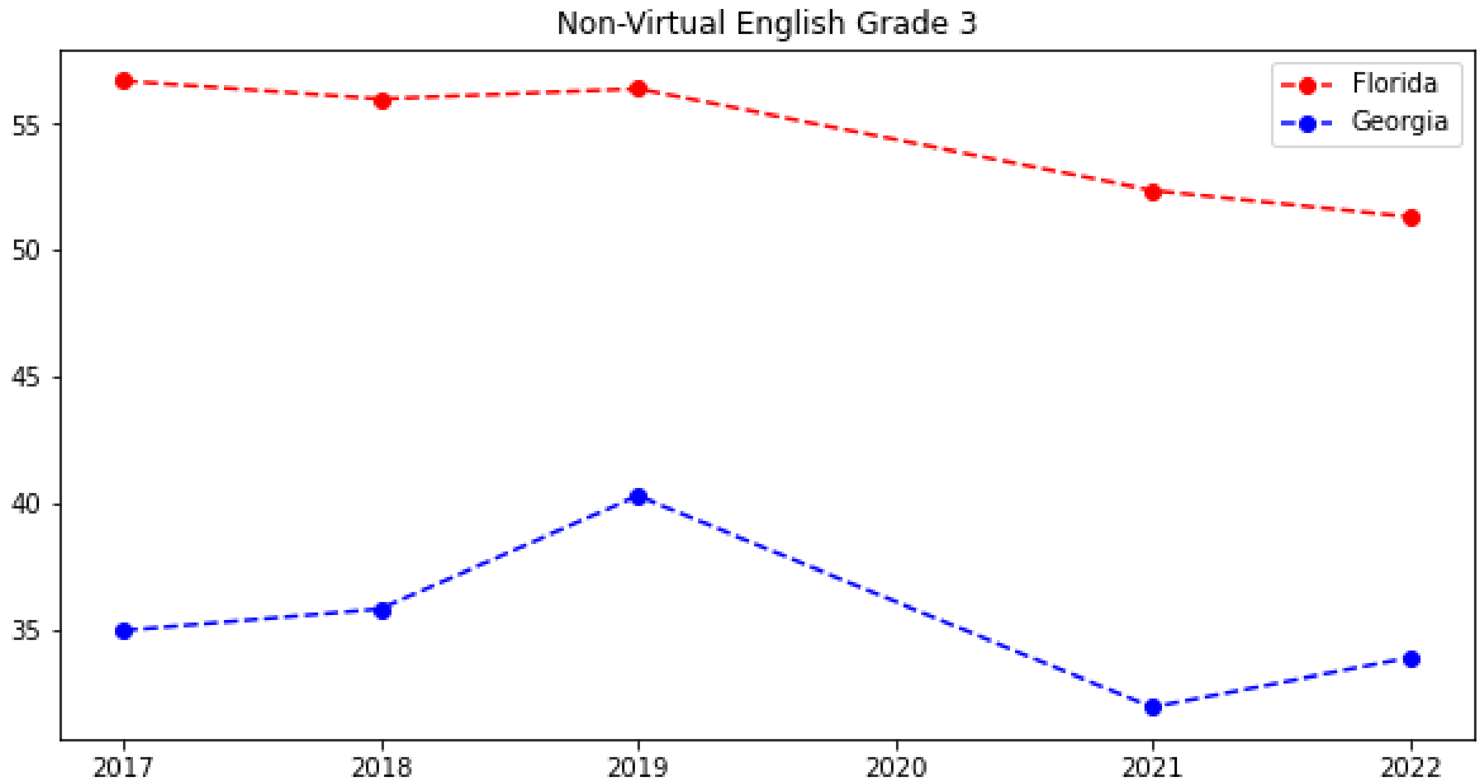
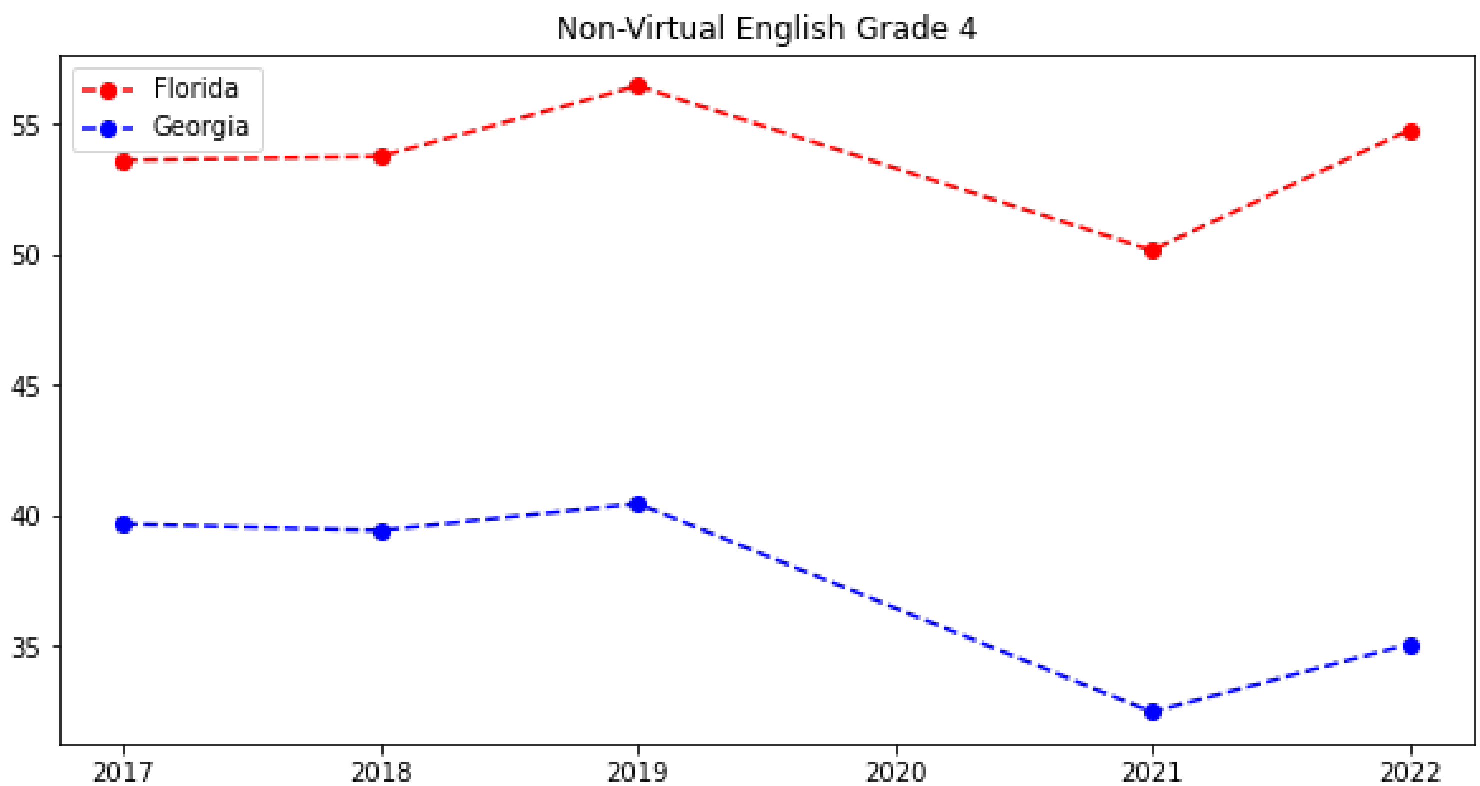
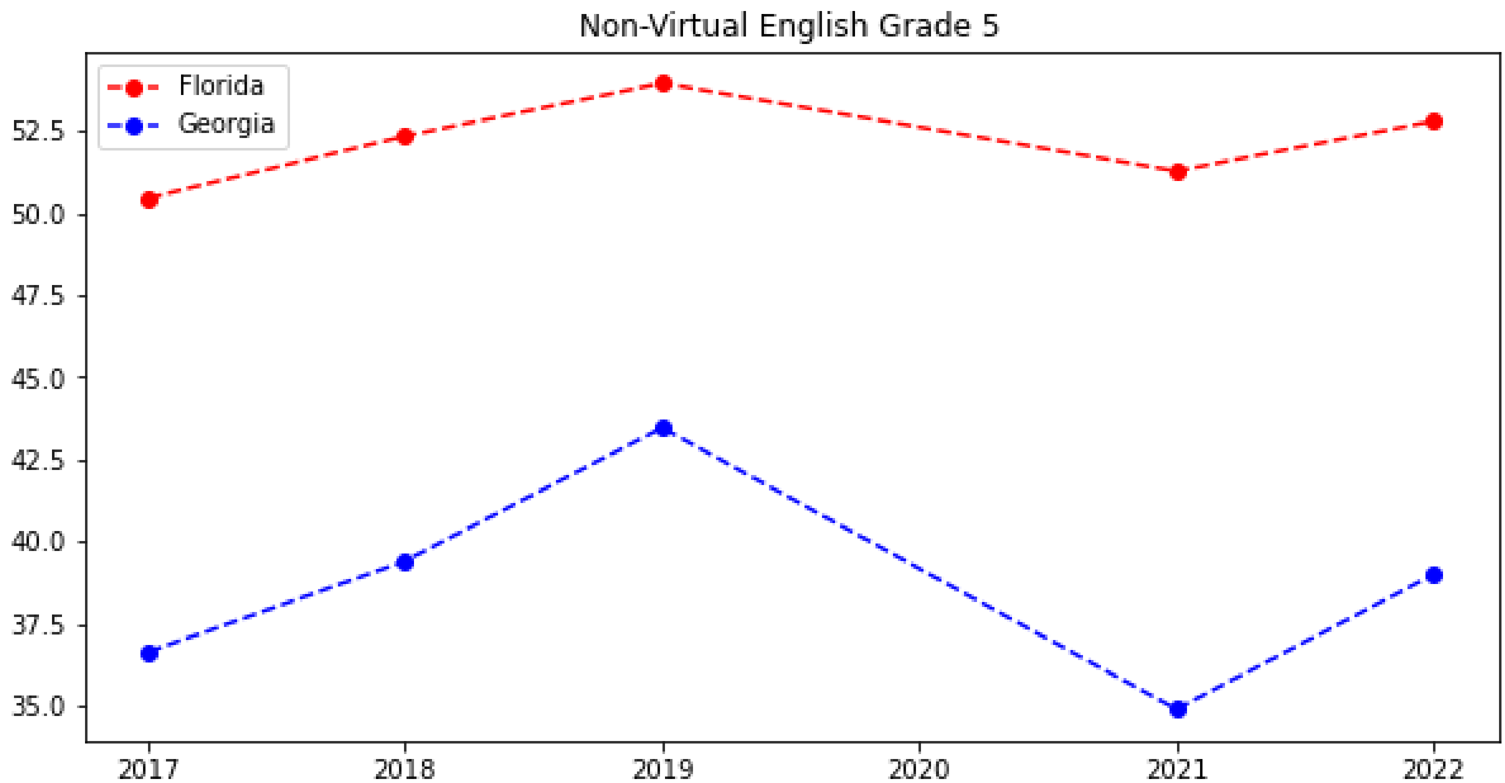
2018
2019
2020
2021
2022

9.3.3 Non-virtual






Non-Virtual English Grade 5
Florida
Georgia
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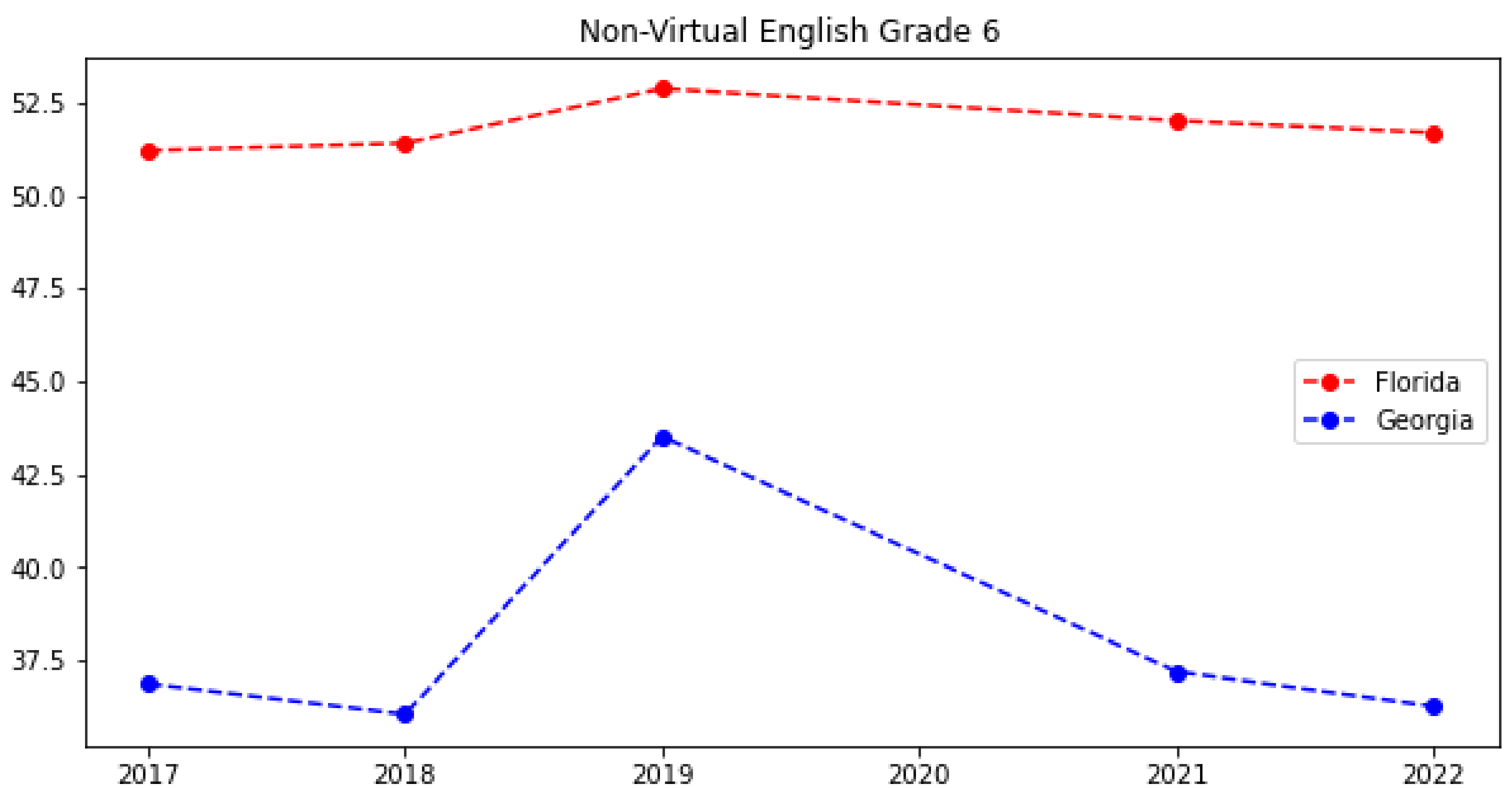
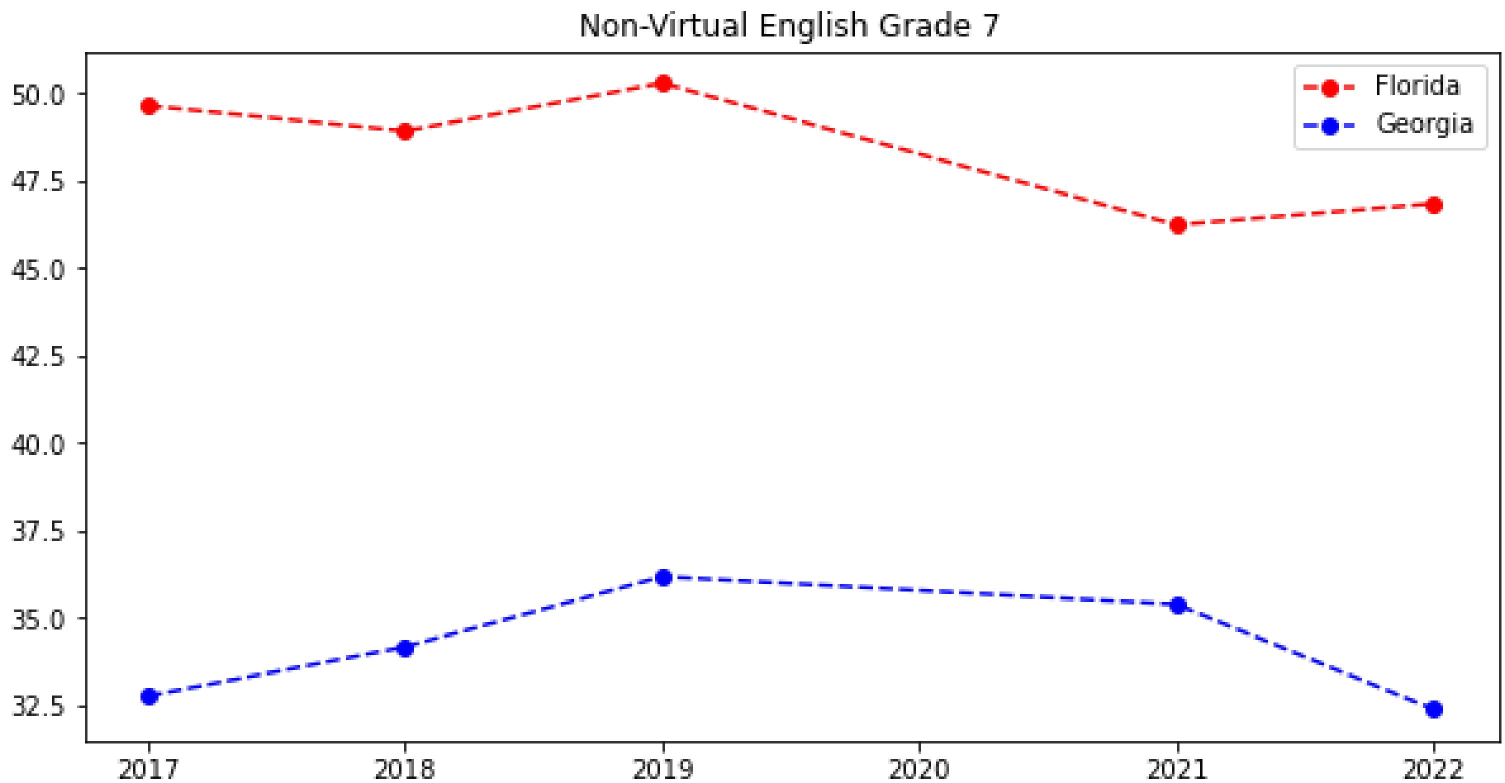
42.5
40.0
37.5
35.0
2017
2018
2019
2020
2021
2022


Non-Virtual English Grade 6
Florida
Georgia
52.5
50.0
47.5
45.0
42.5
40.0
37.5
2017
2018
2019
2020
2021
2022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Florida
Georgia
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32.5
2017
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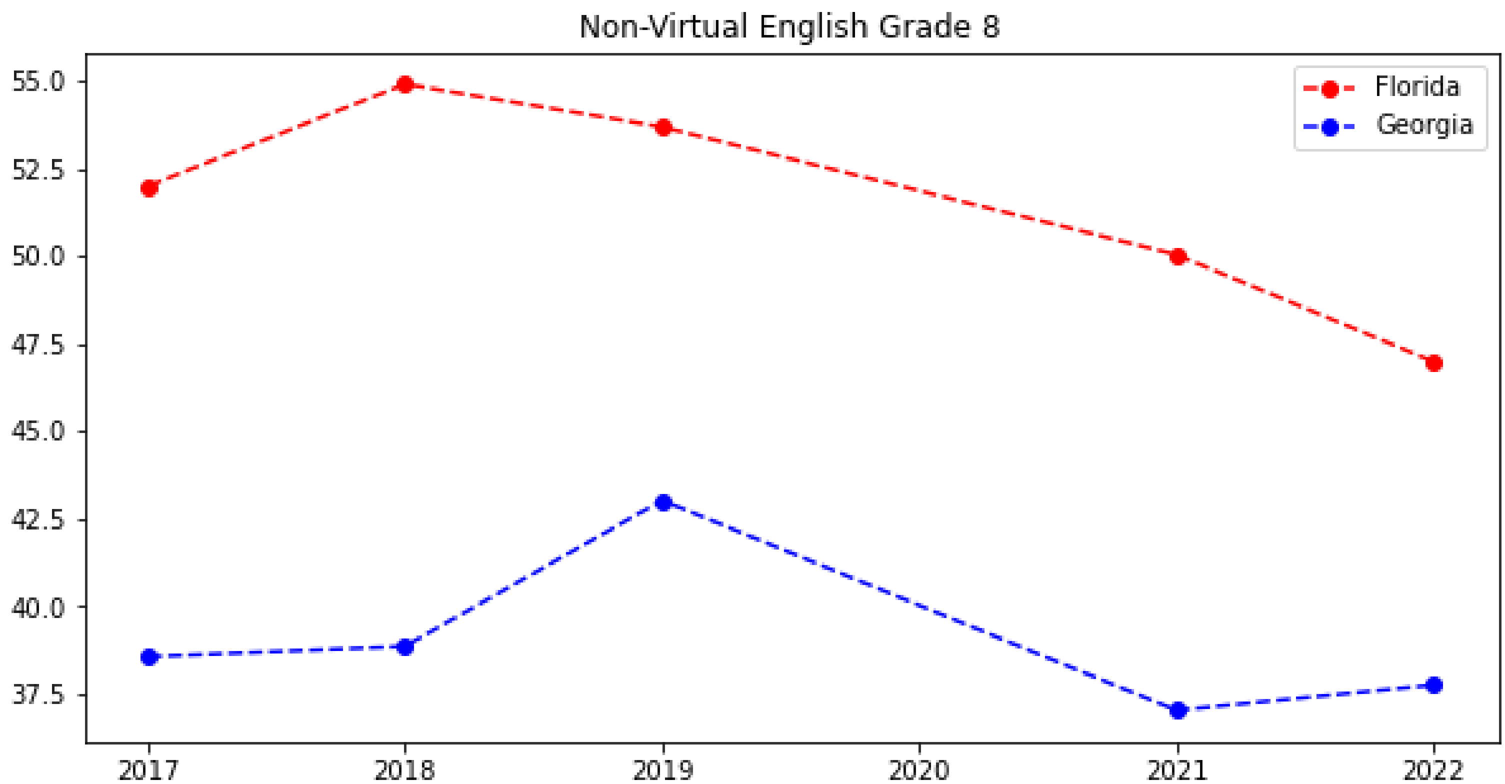
2019
2020
2021
2022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Florida
Georgia
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2018
2019
2020
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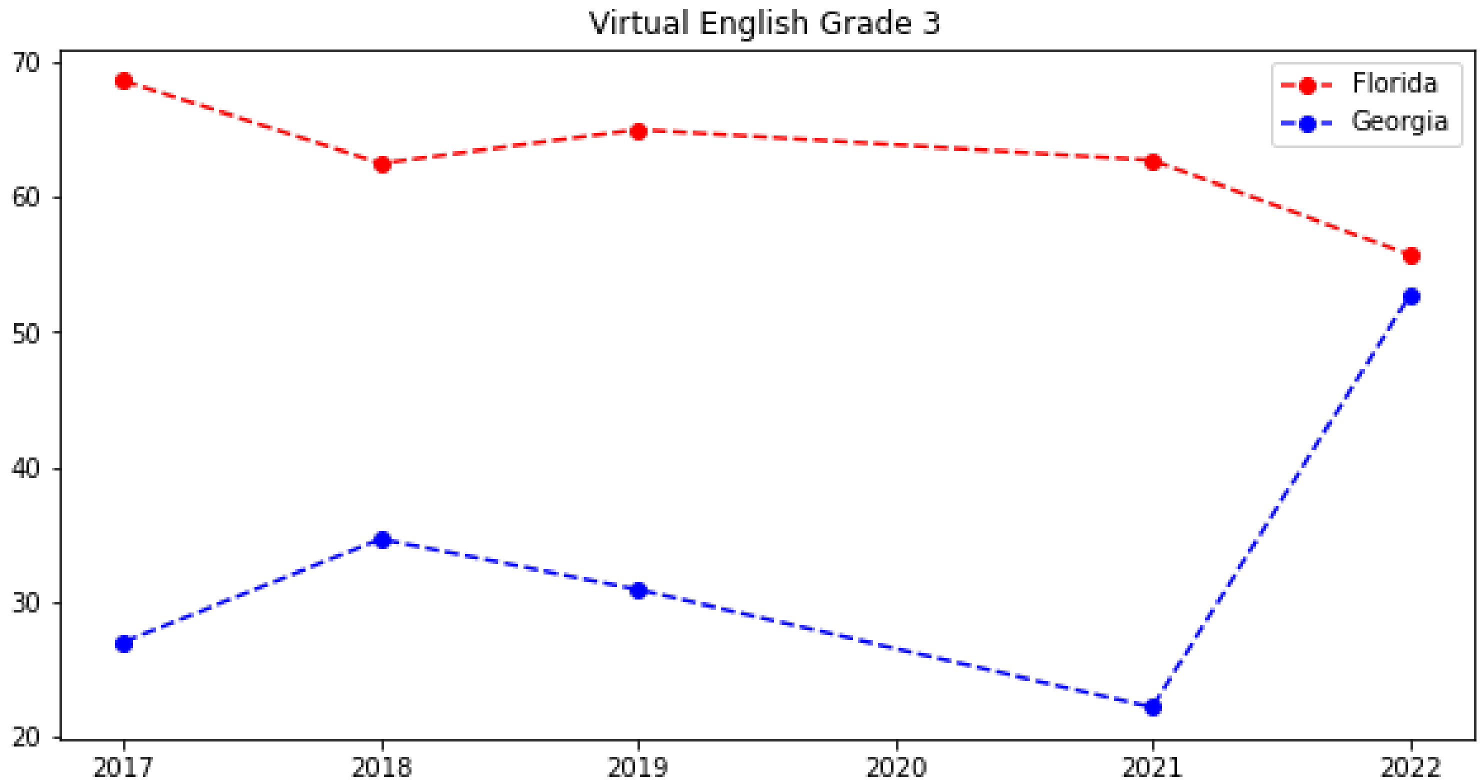
2022

9.3.4 Virtual



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Georgia
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2021
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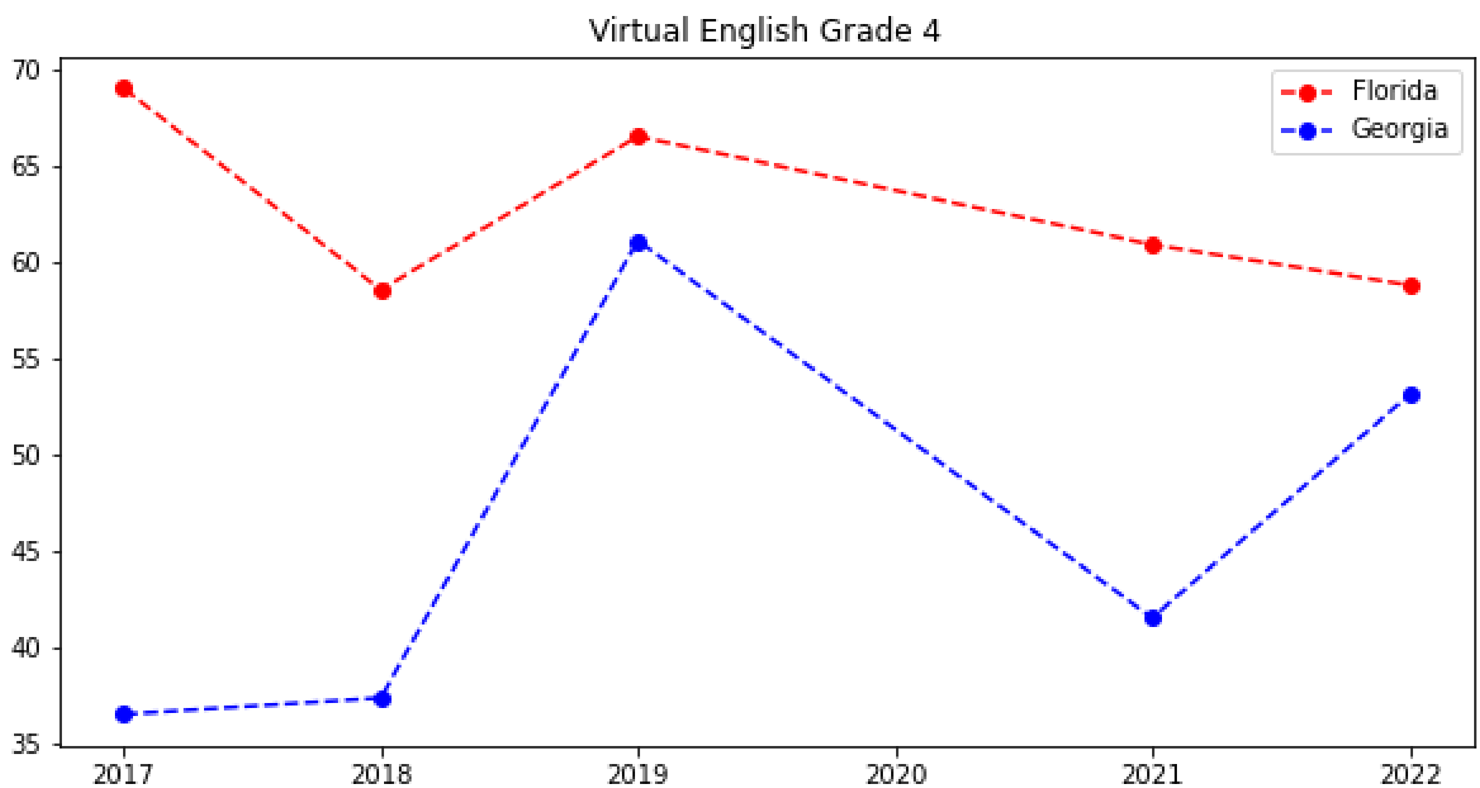

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Georgia
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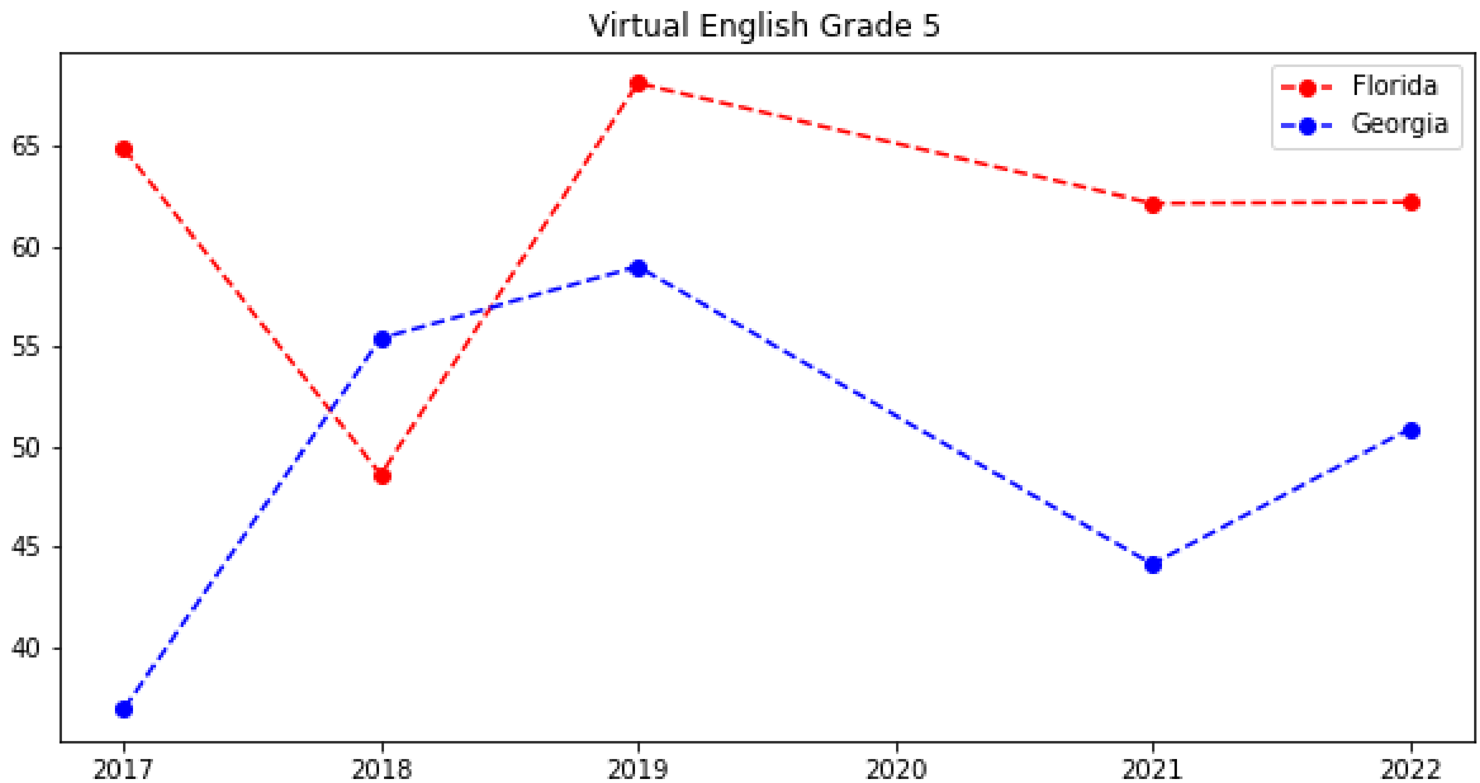
2022



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Florida
Georgia
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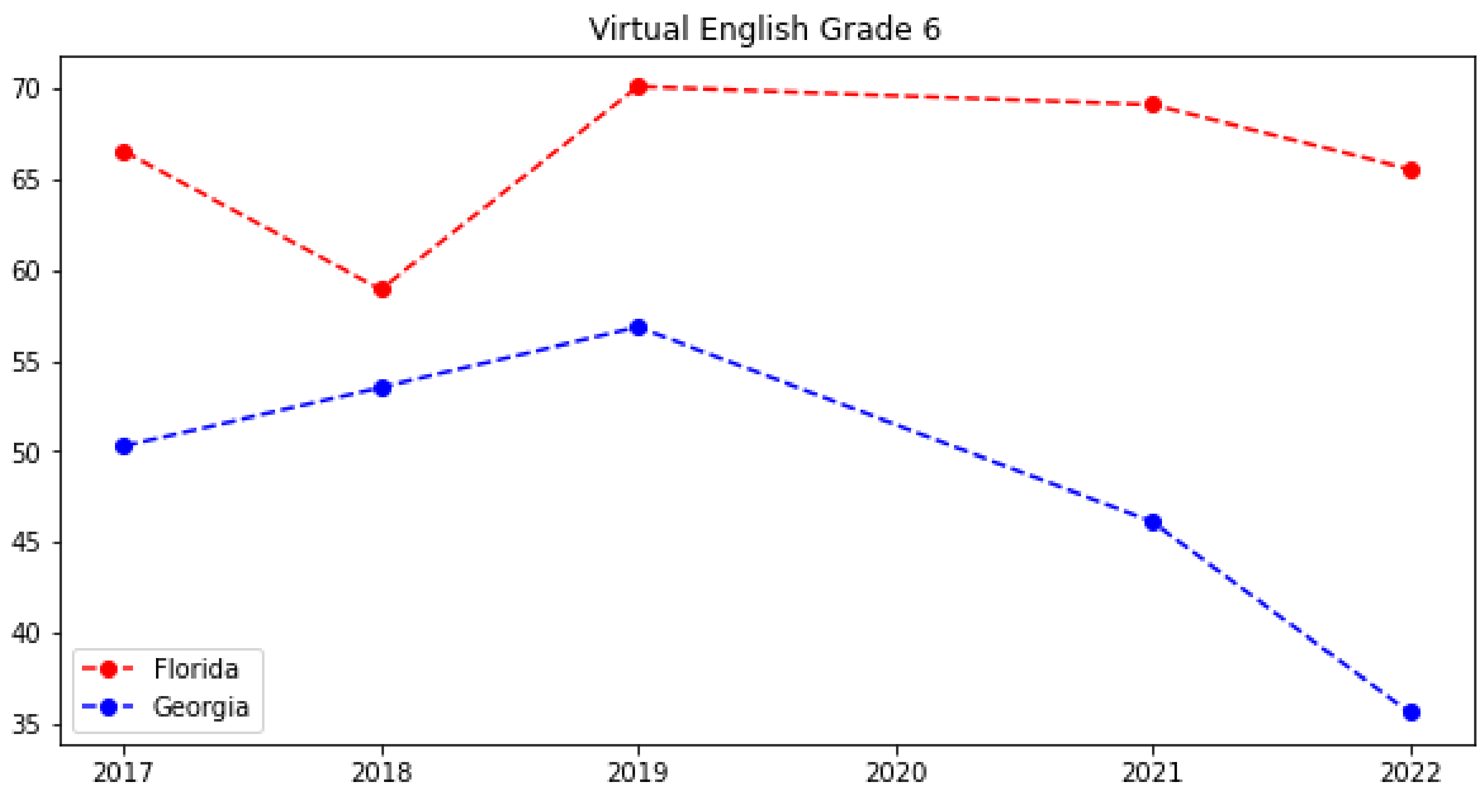
2022



Virtual English Grade 6
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Georgia
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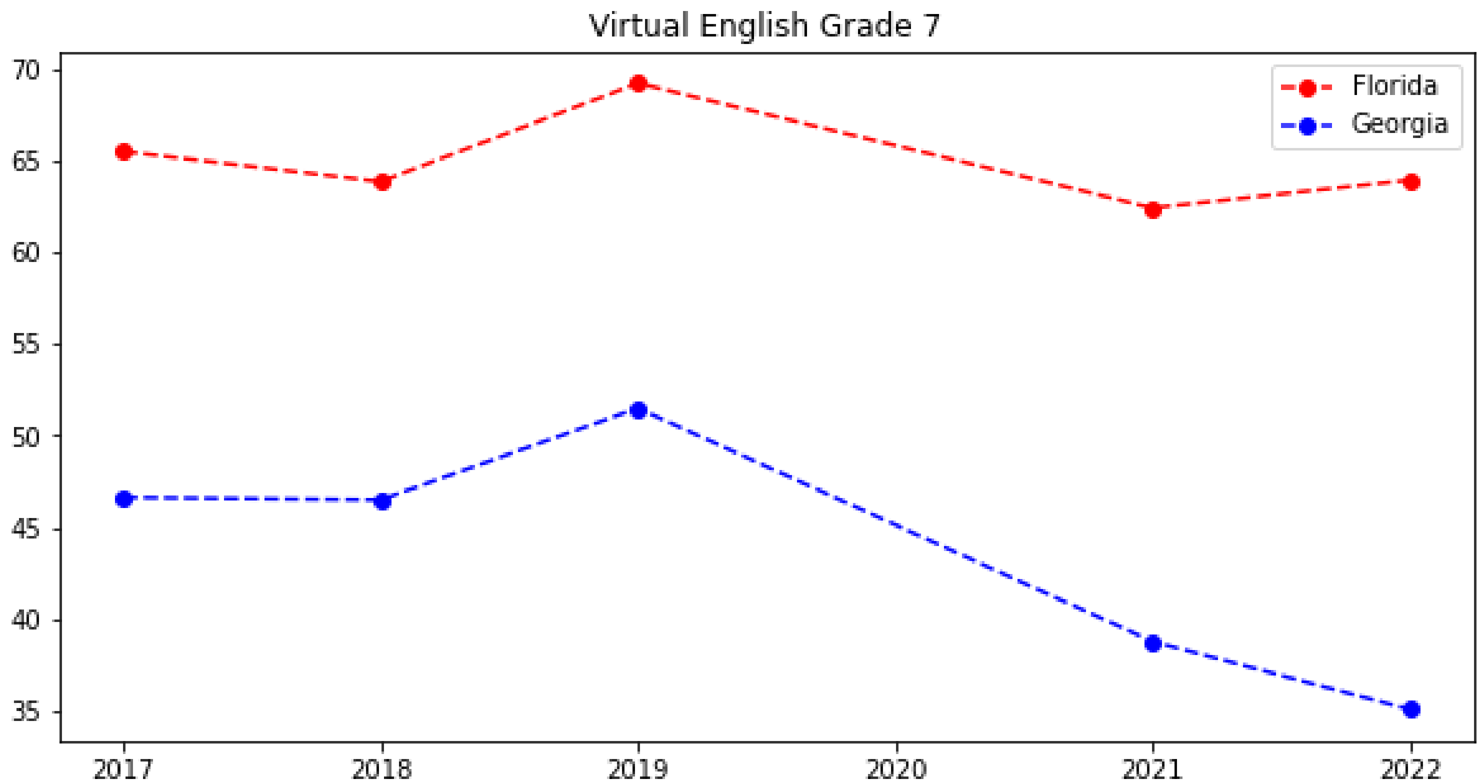
2019
2020
2021
2022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Georgia
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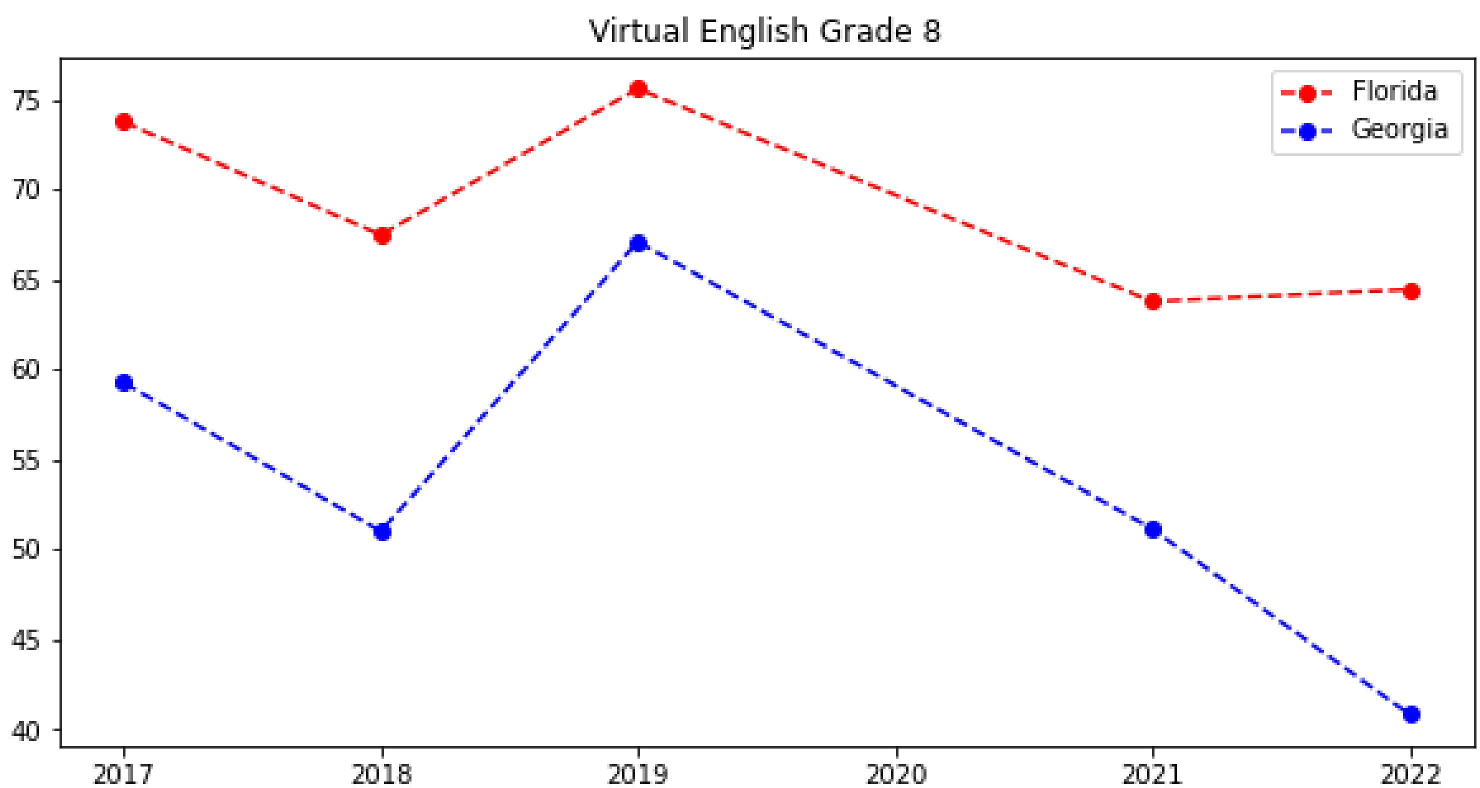
2021
2022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Florida
Georgia
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2017
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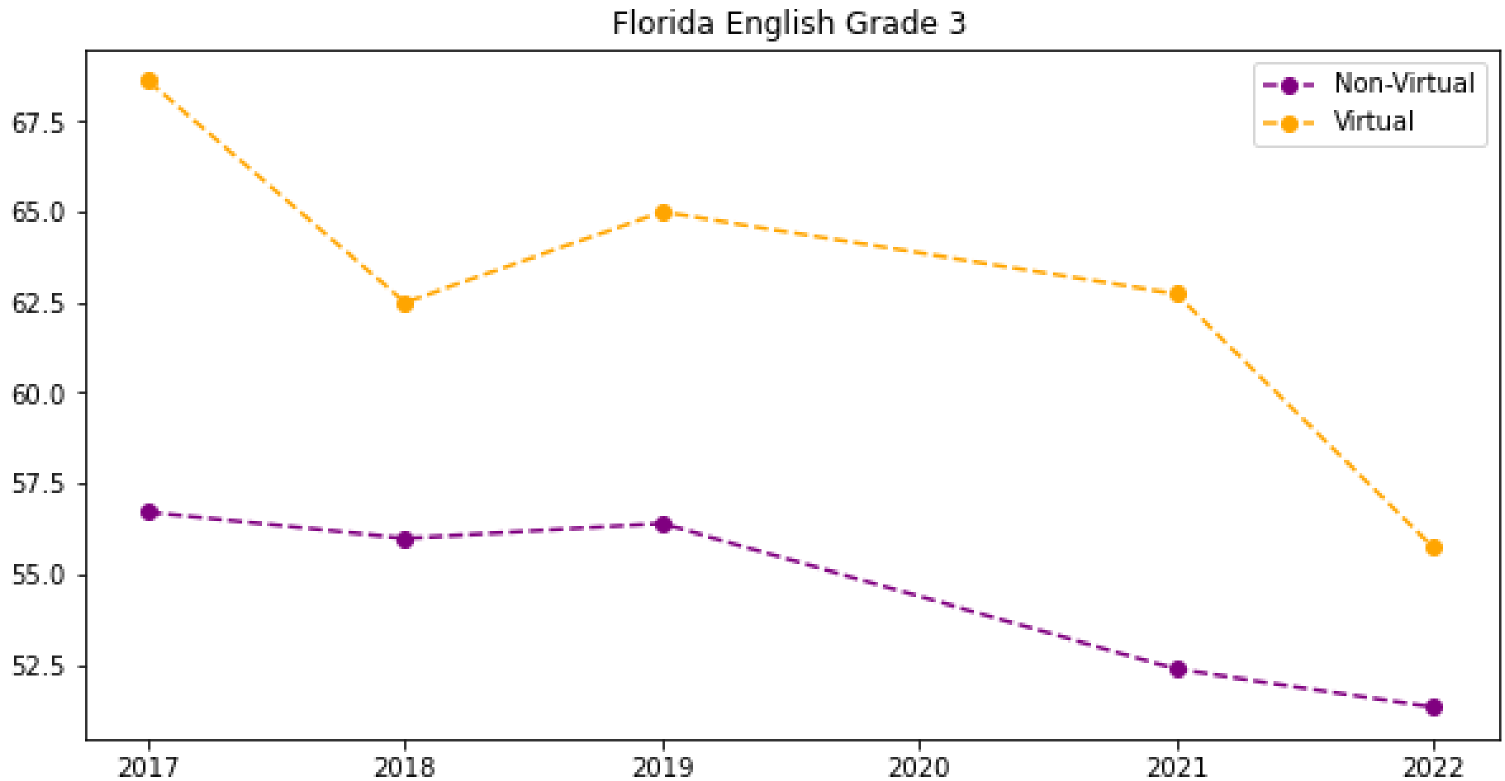
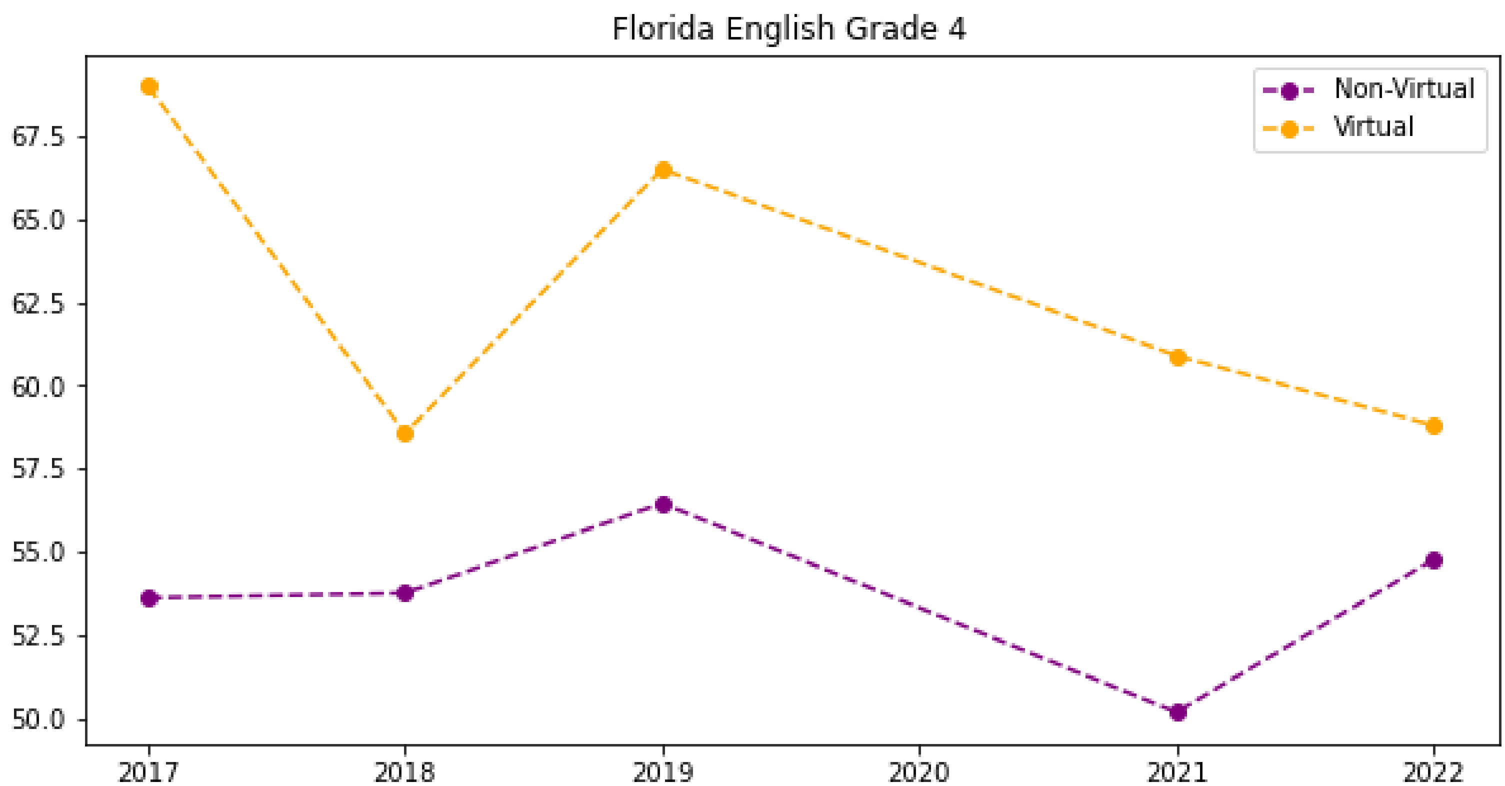
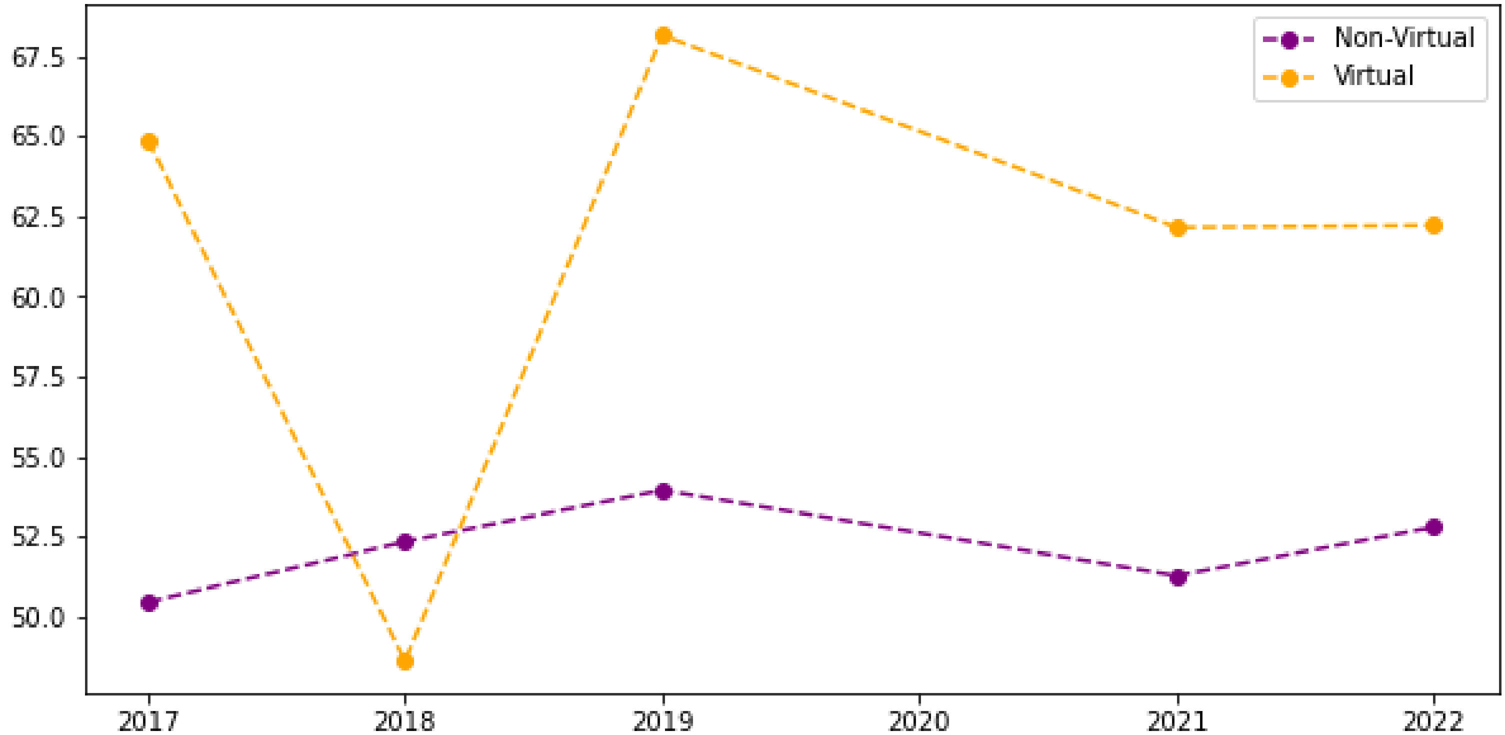
2019
2020
2021
2022

9.3.5 Florida virtual and non-virtual

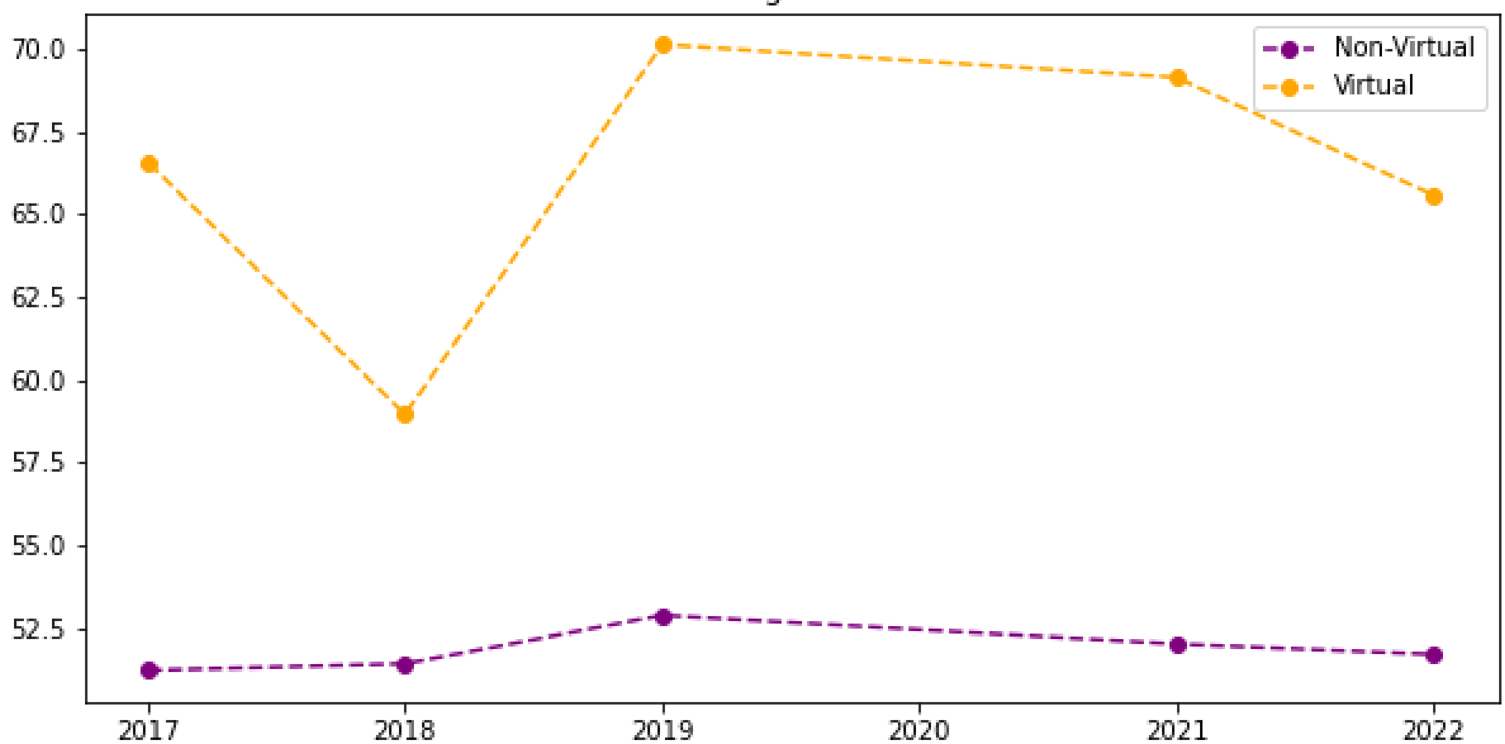


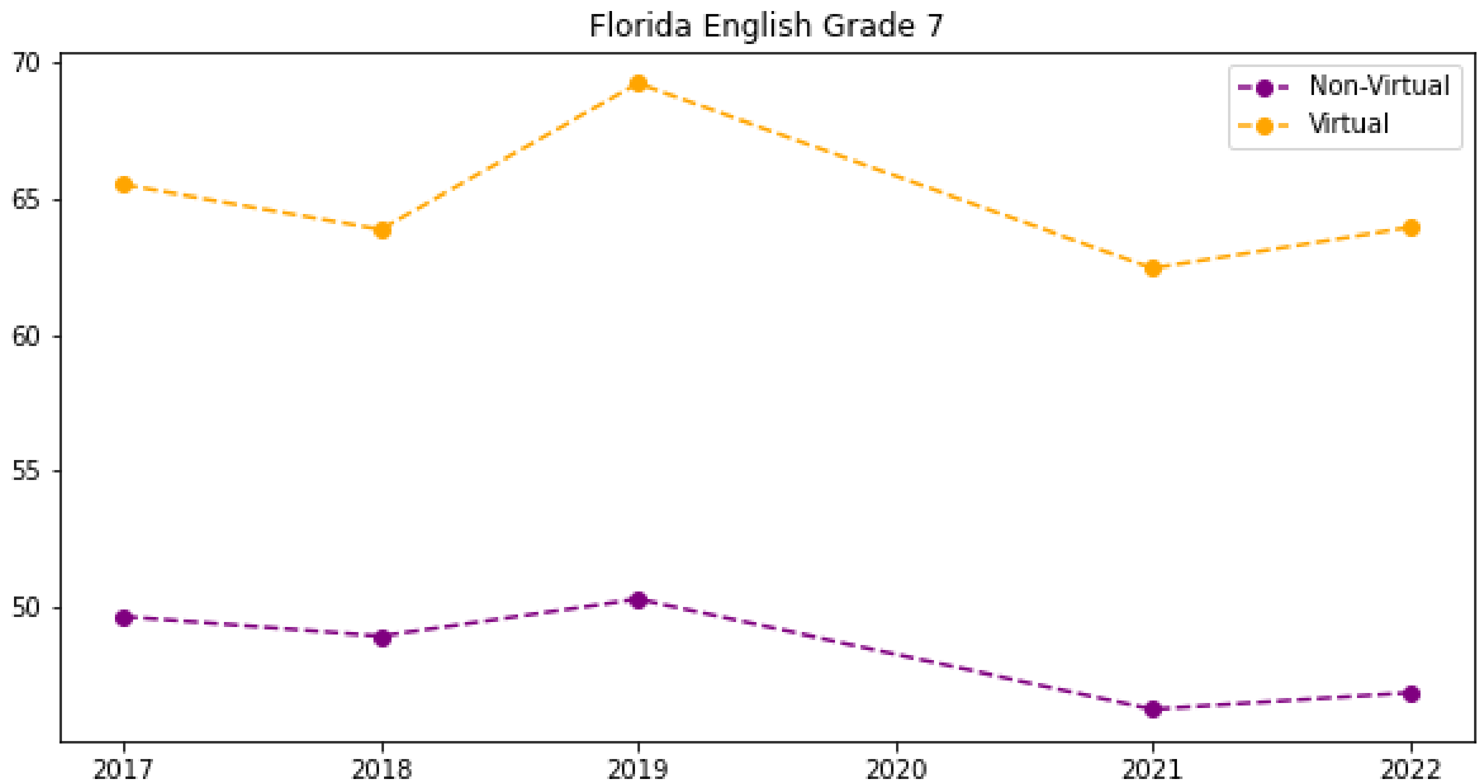


Florida English Grade 5



Florida English Grade 6

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Virtual
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2017
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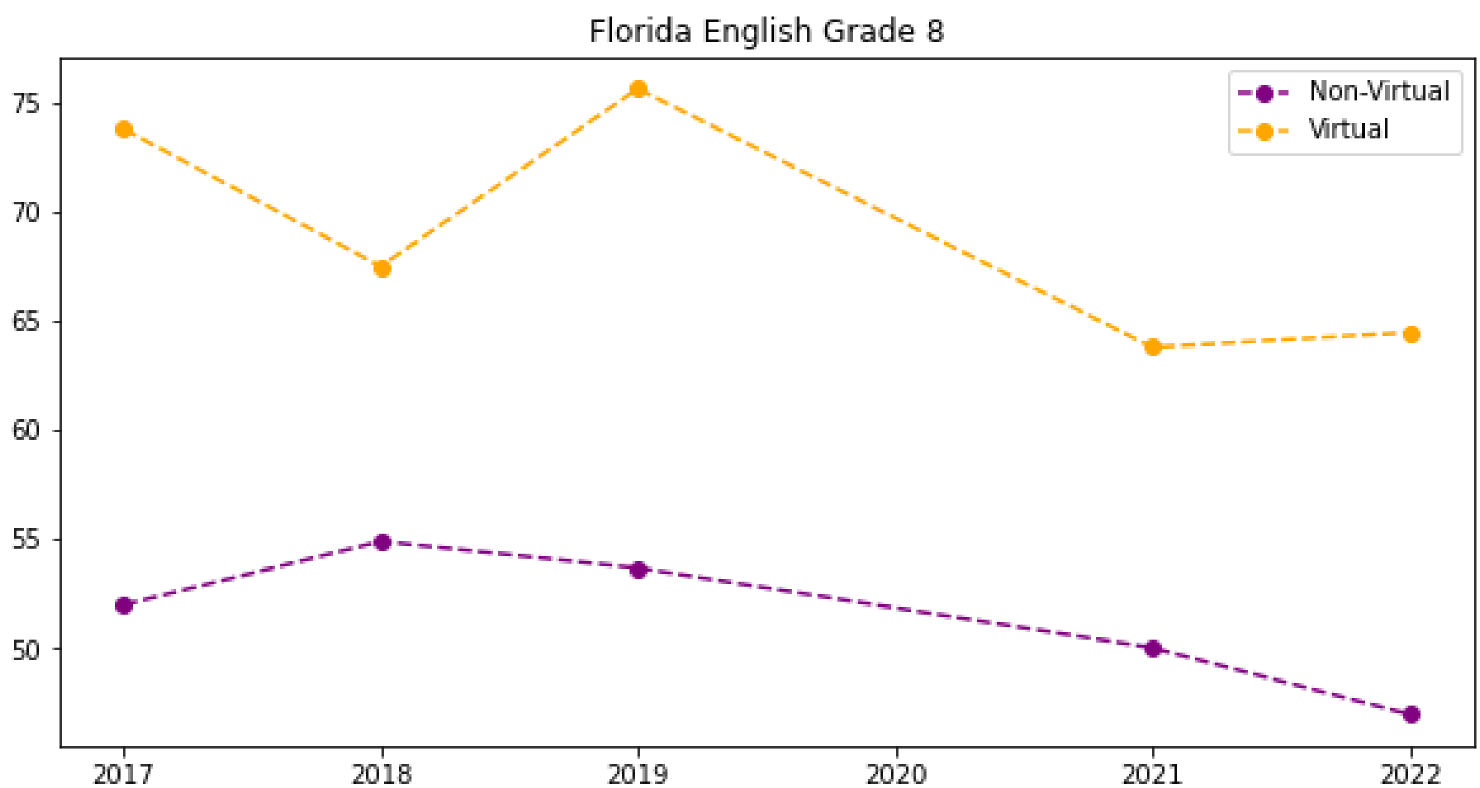
2019
2020
2021
2022


Florida English Grade 8
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Virtual
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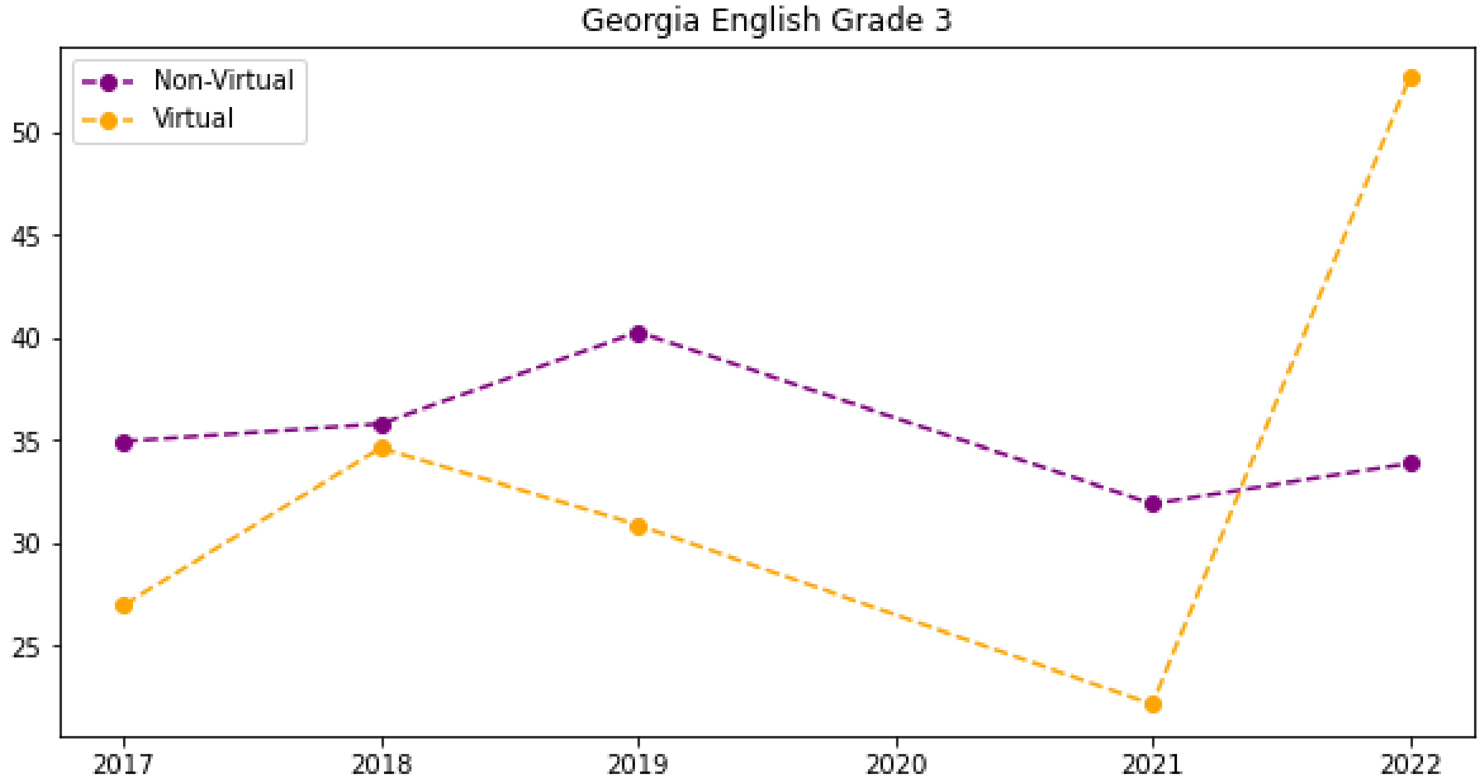
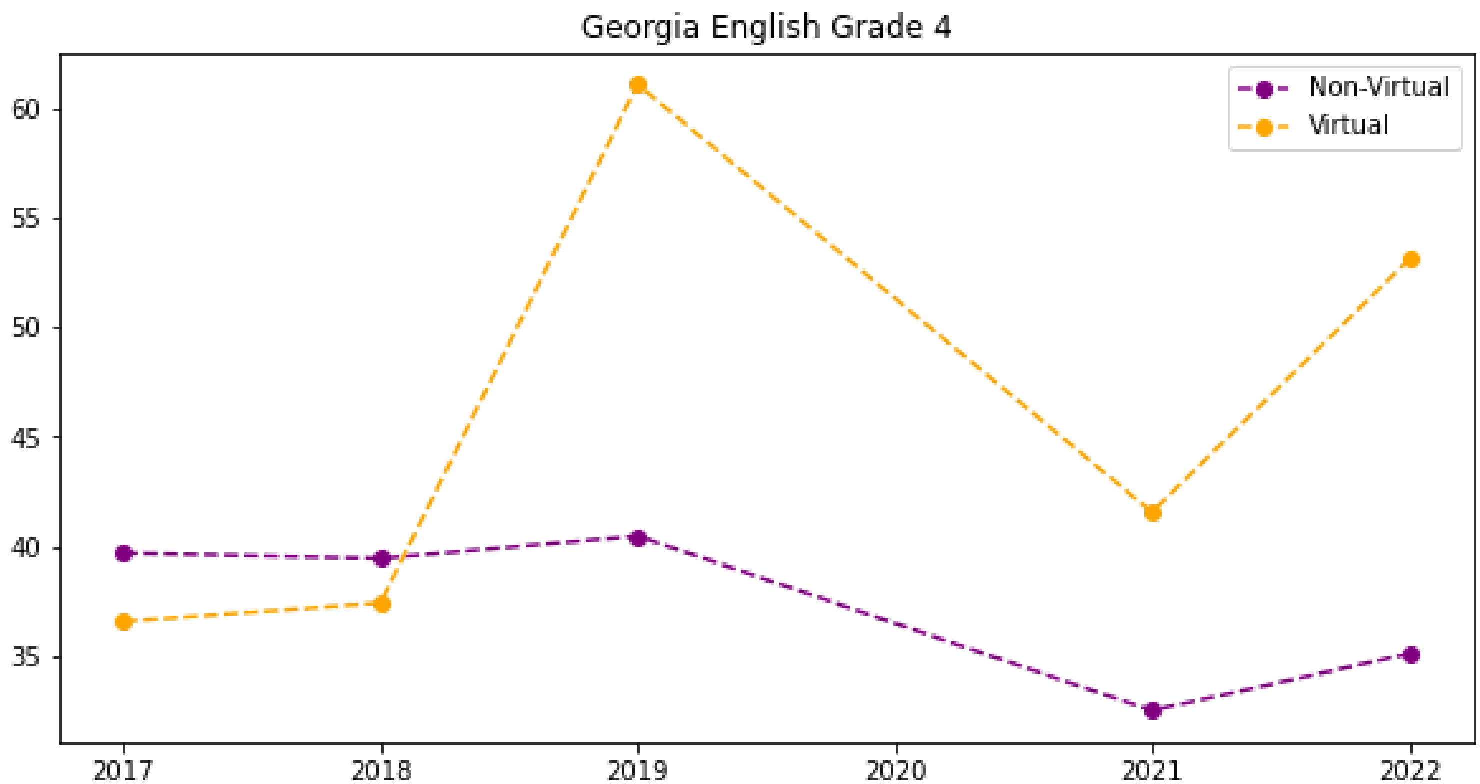
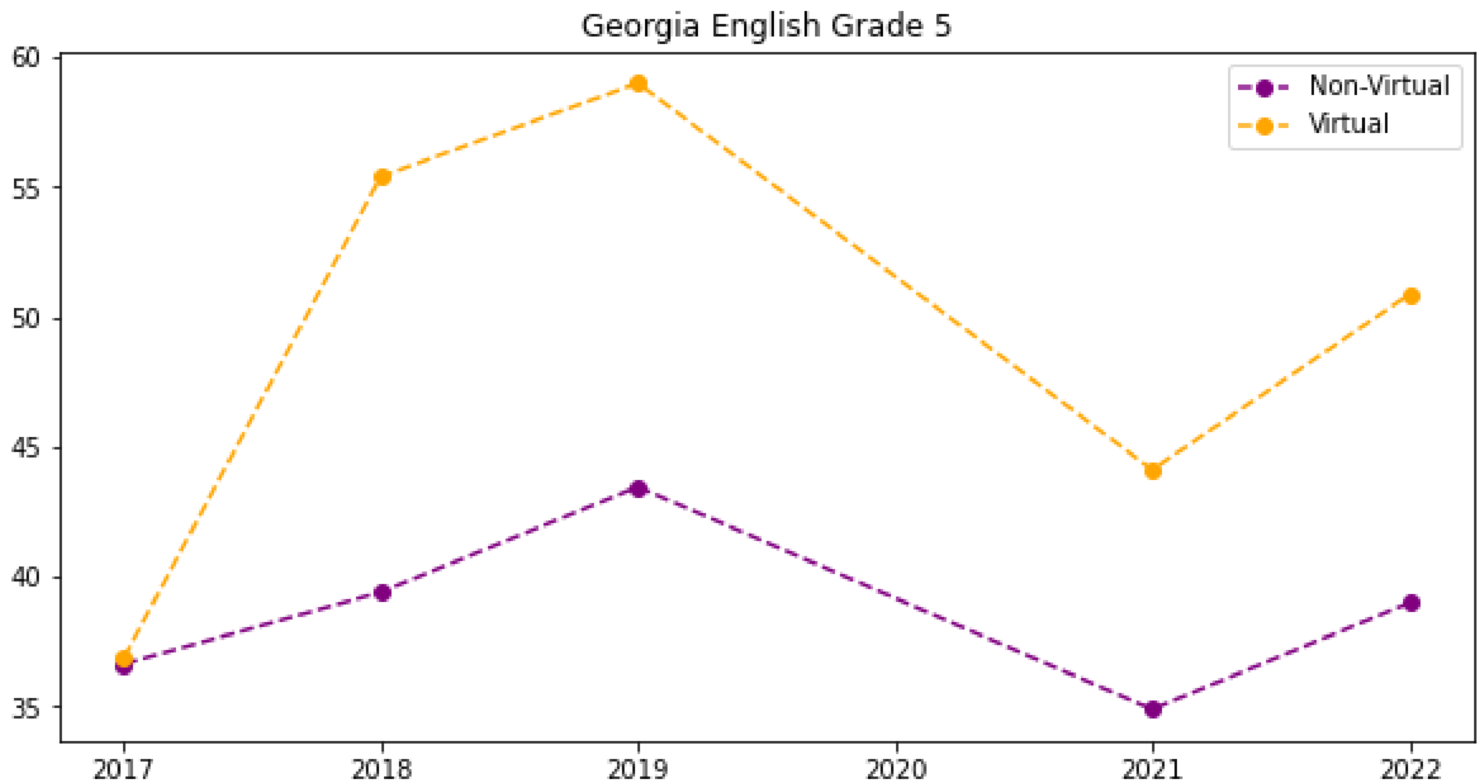
50
2017
2018
2019
2020
2021
2022

9.3.6 Georgia virtual and non-virtual



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Non-Virtual
Virtual
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35
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2019
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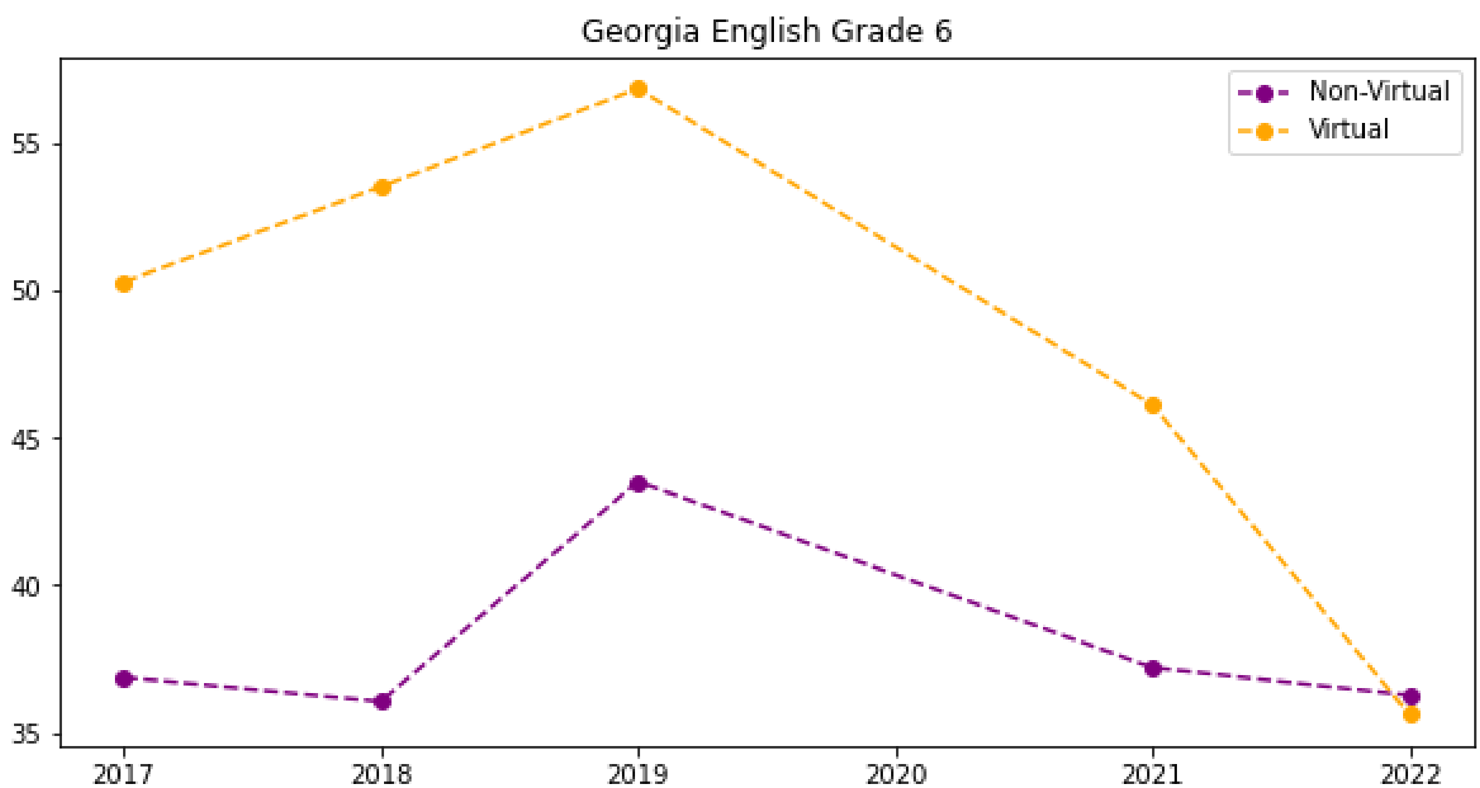
2021
2022


Georgia English Grade 6
Non-Virtual
Virtual
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35
2017
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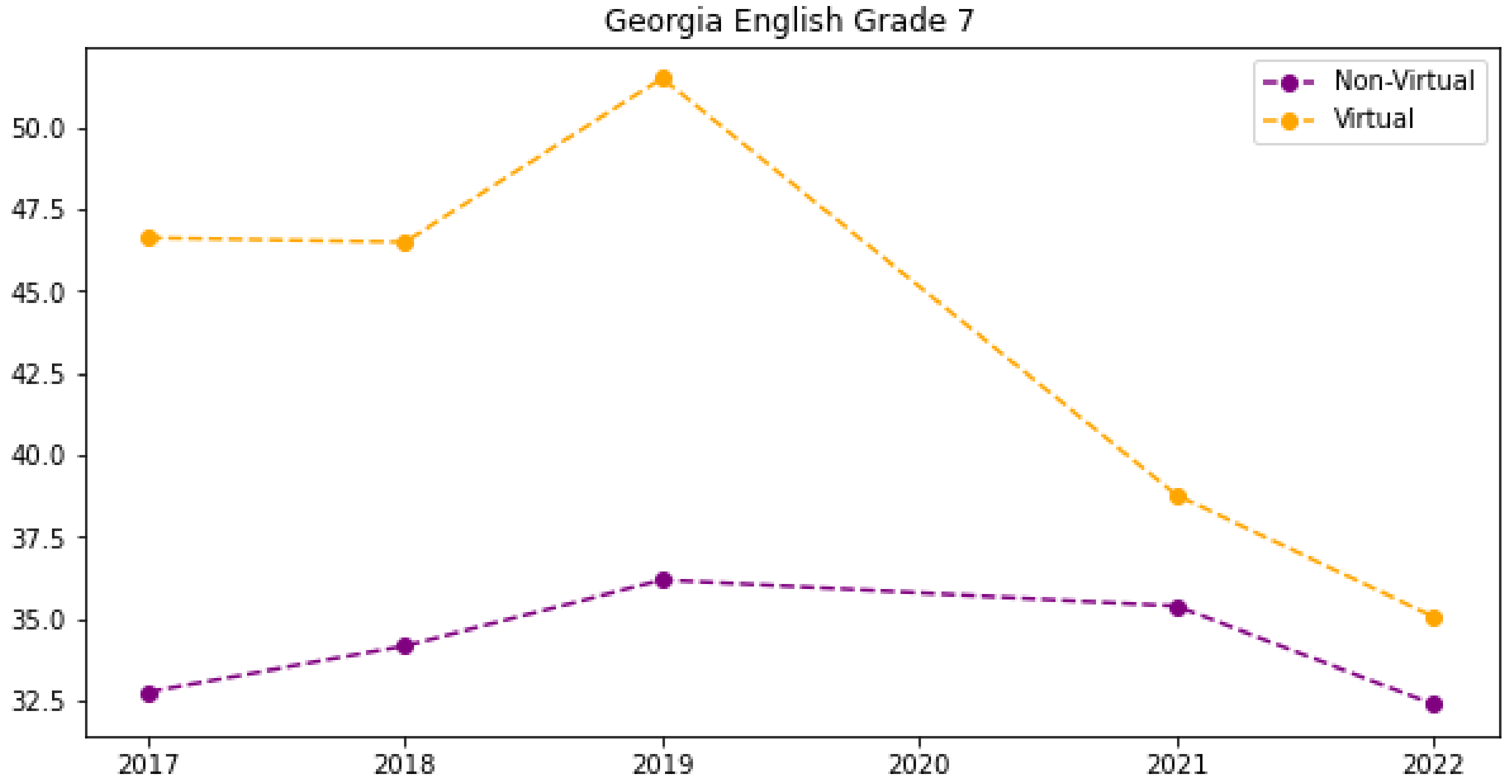
2019
2020
2021
2022


Georgia English Grade 7
Non-Virtual
Virtual
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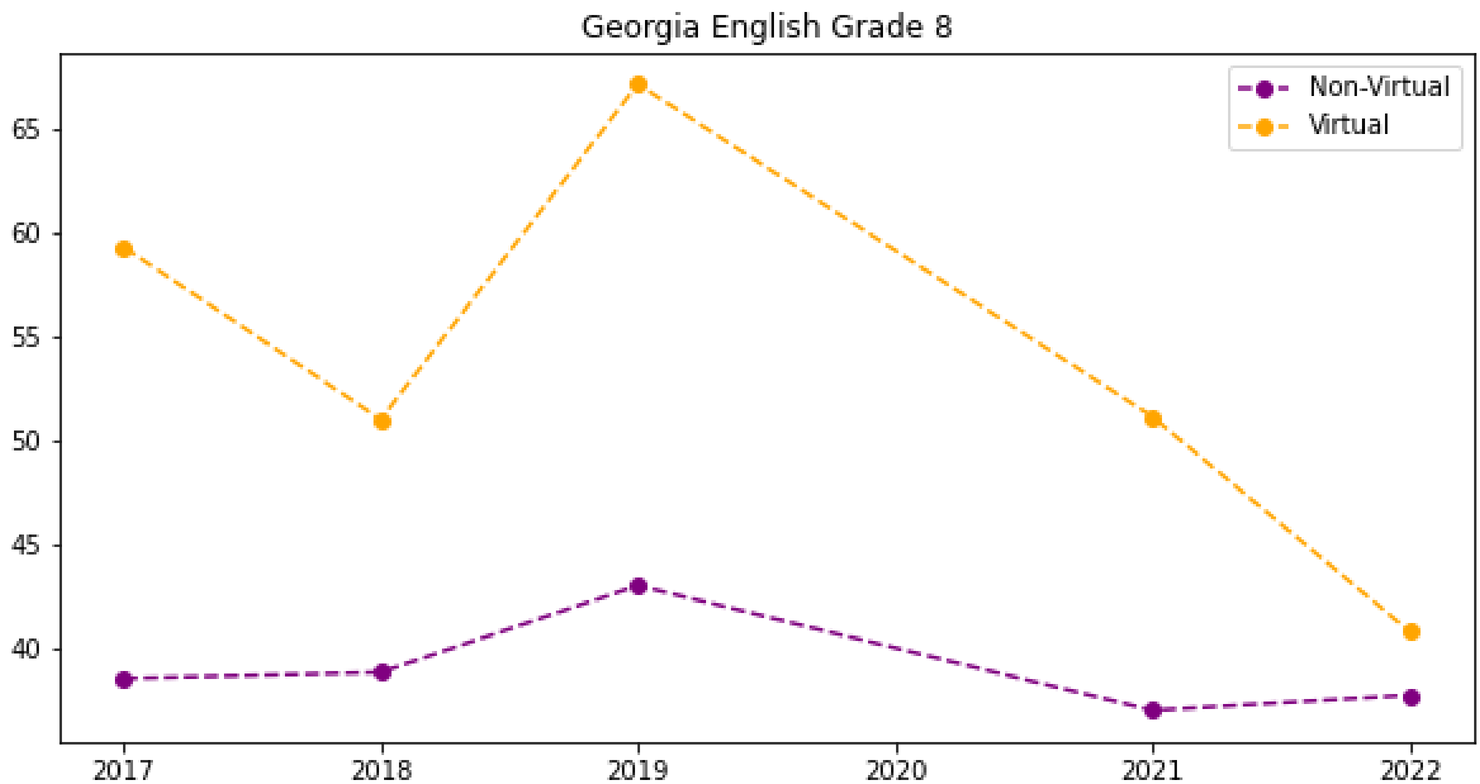
47.5
45.0
42.5
40.0
37.5
35.0
32.5
2017
2018
2019
2020
2021
2022


Georgia English Grade 8
Non-Virtual
Virtual
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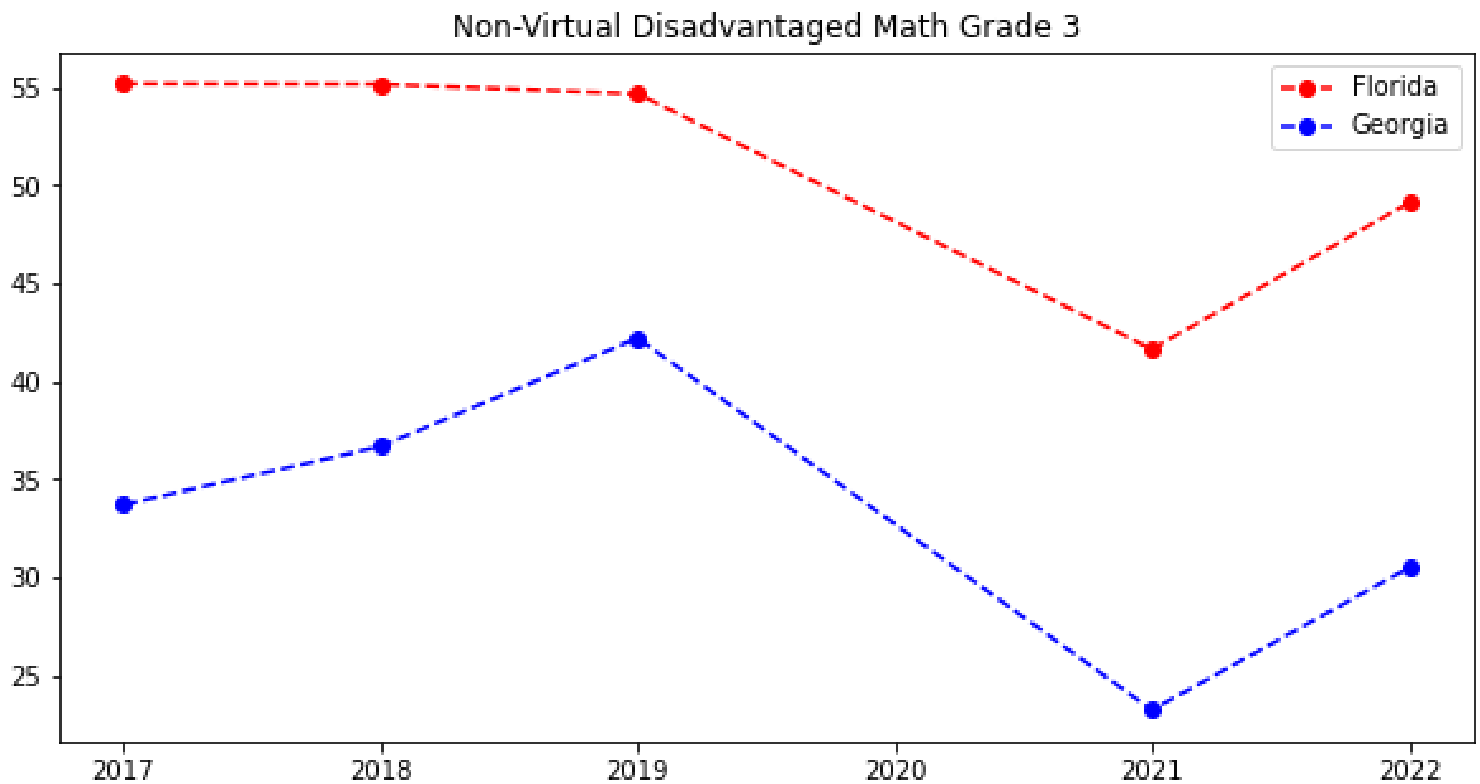
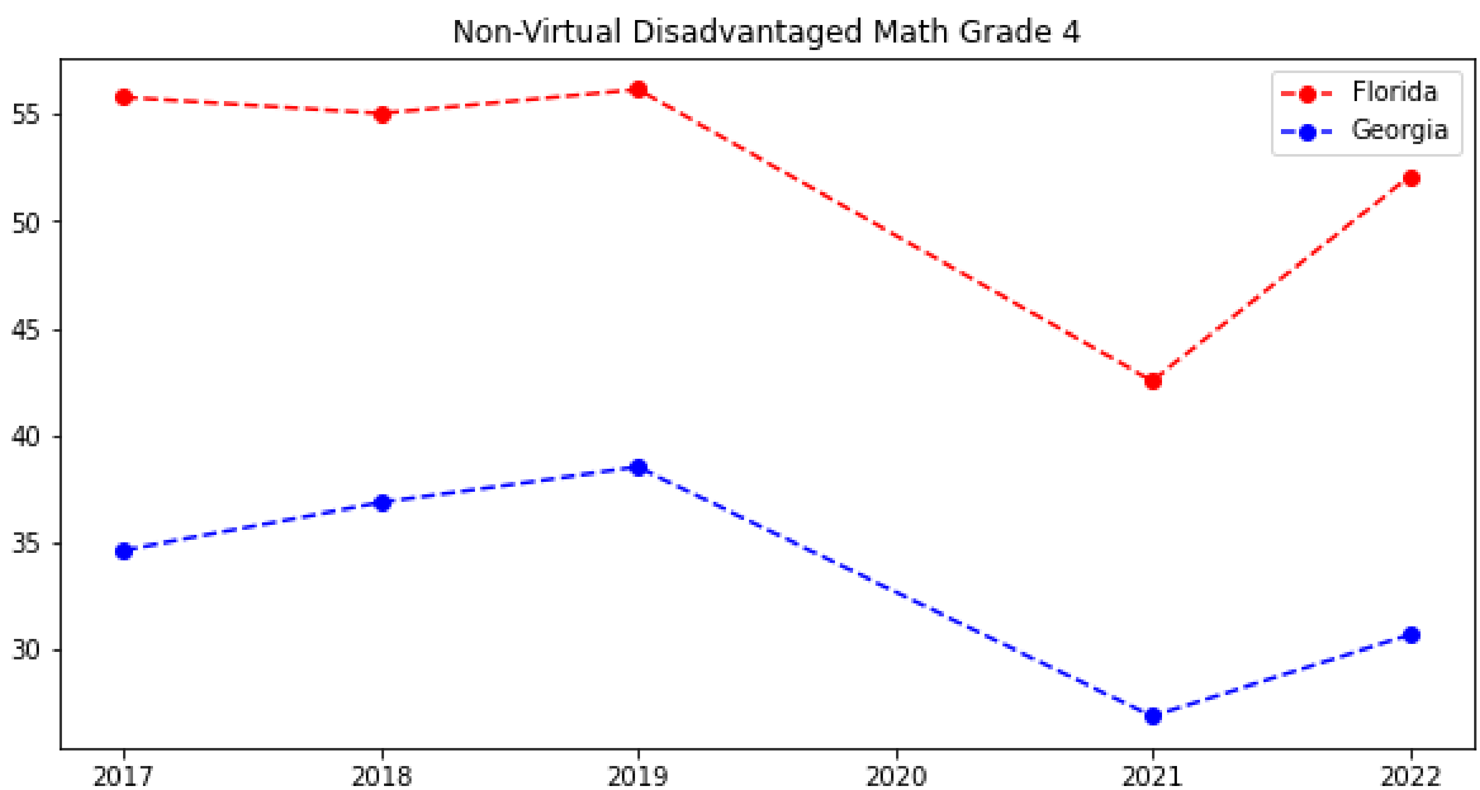
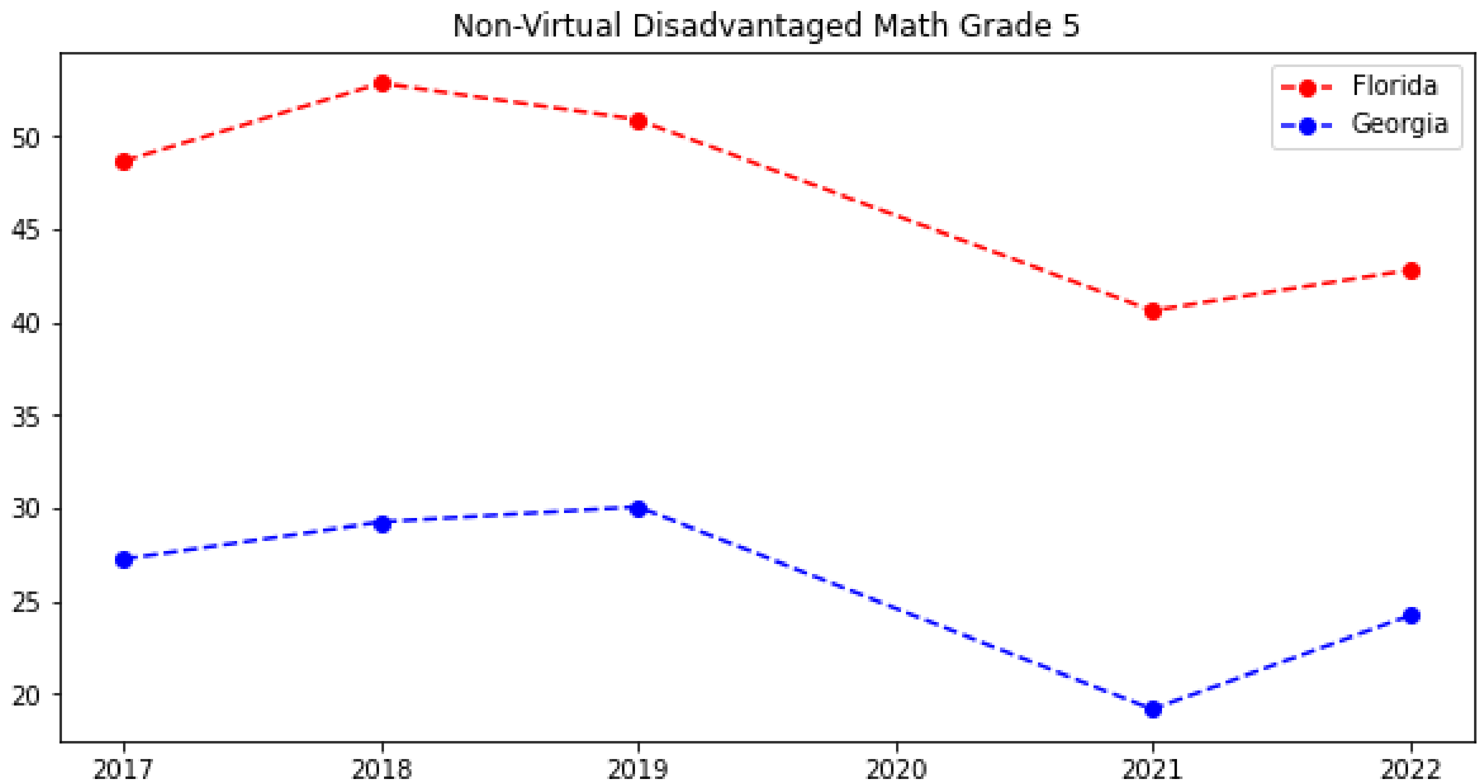
50
45
40
2017
2018
2019
2020
2021
2022

9.4 Math Graphs

9.4.1 Non-virtual disadvantaged



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Georgia
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2017
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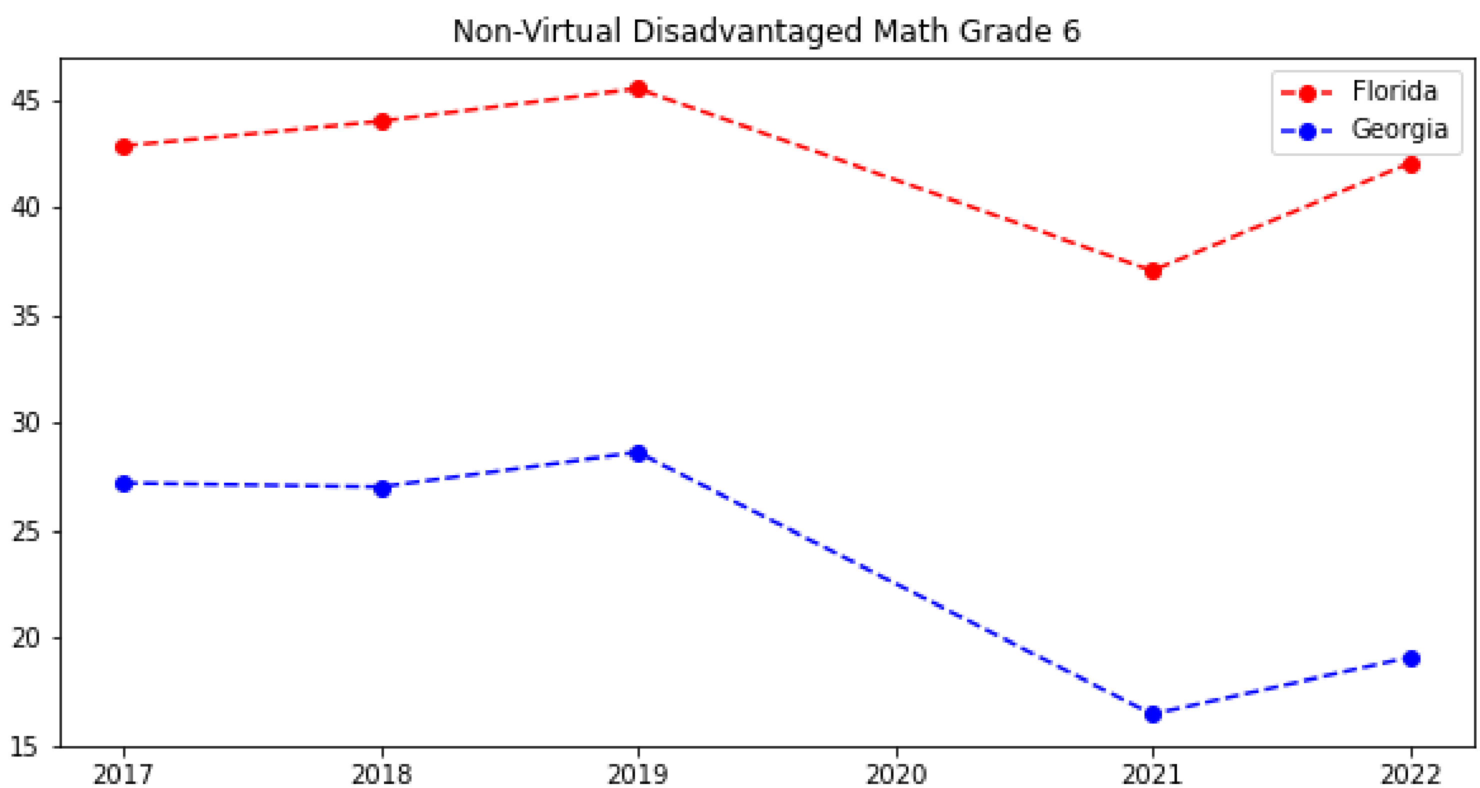
2022


Non-Virtual Disadvantaged Math Grade 6
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Georgia
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2017
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2020
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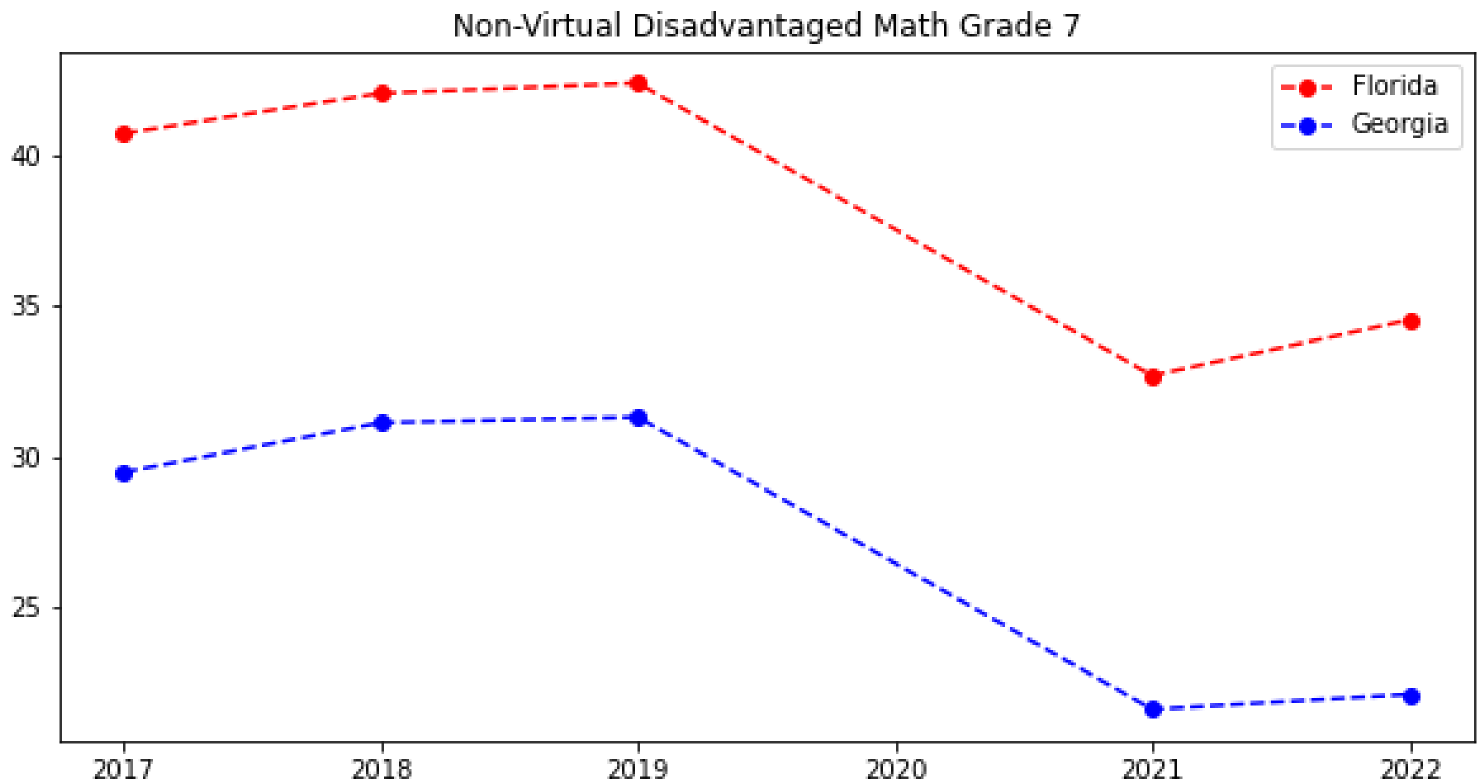
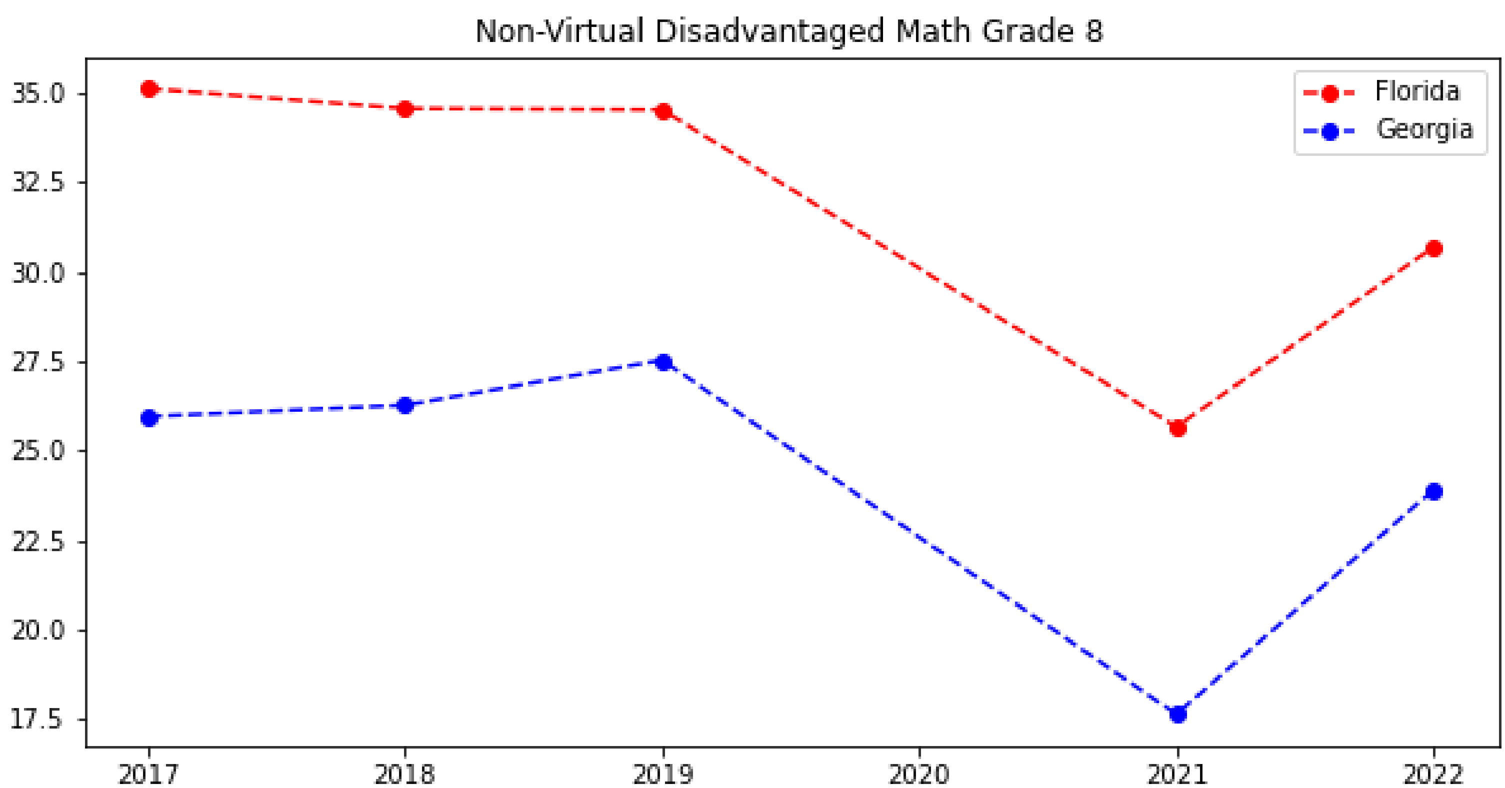
2022


Non-Virtual Disadvantaged Math Grade 7
Florida
Georgia
40
35
30
25
2017
2018
2019
2020
2021
2022


Non-Virtual Disadvantaged Math Grade 8
Florida
Georgia
35.0
32.5
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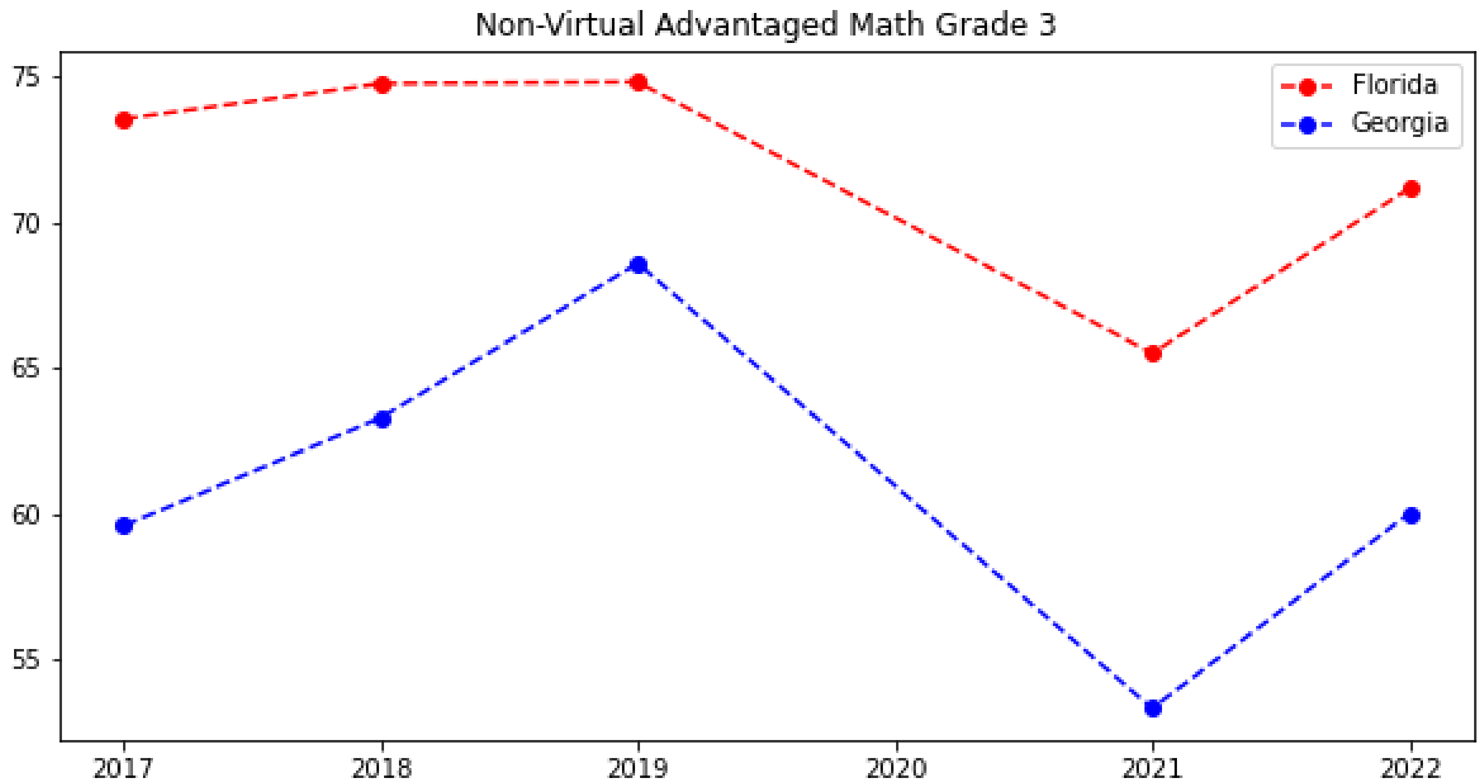
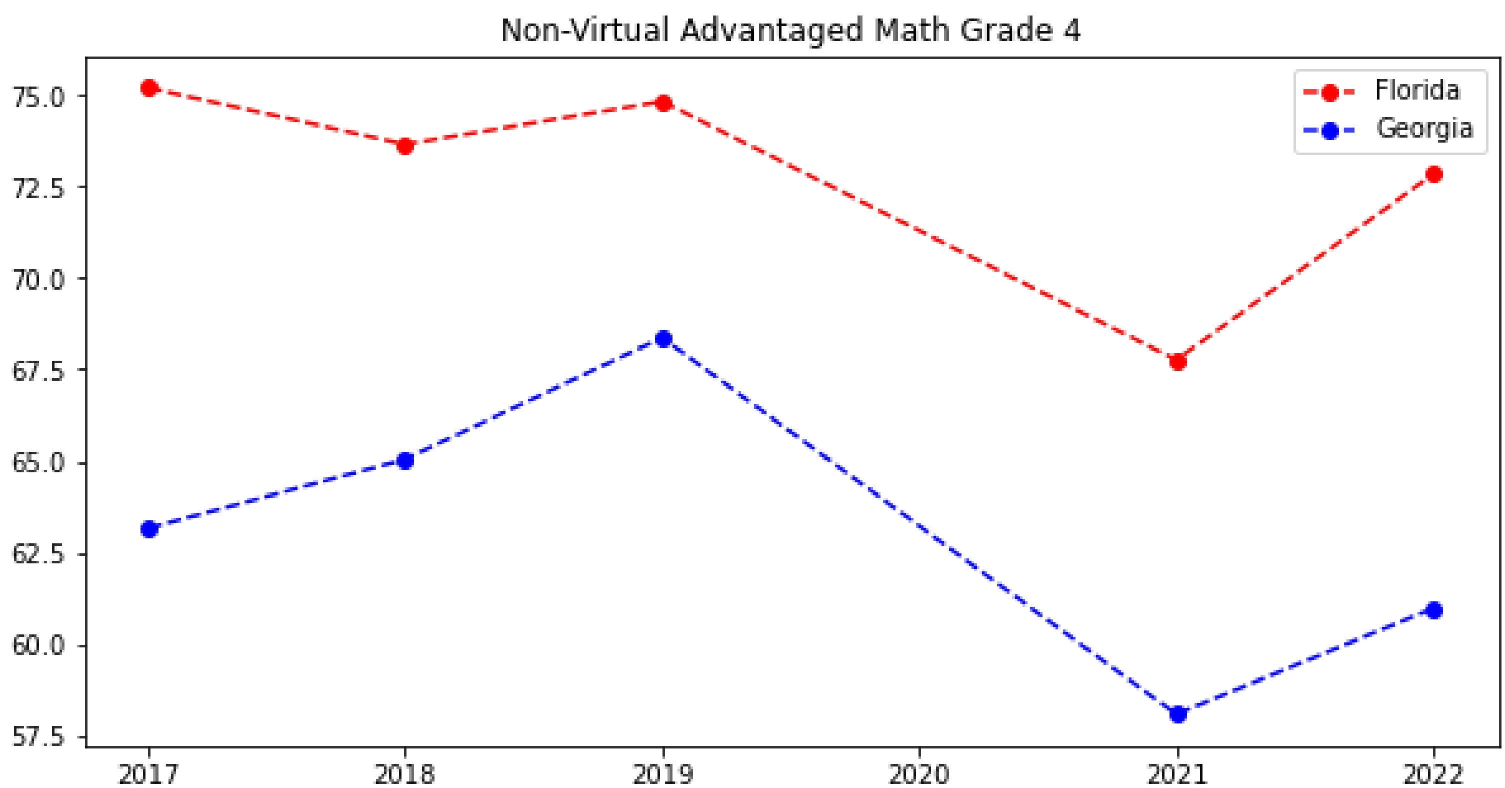
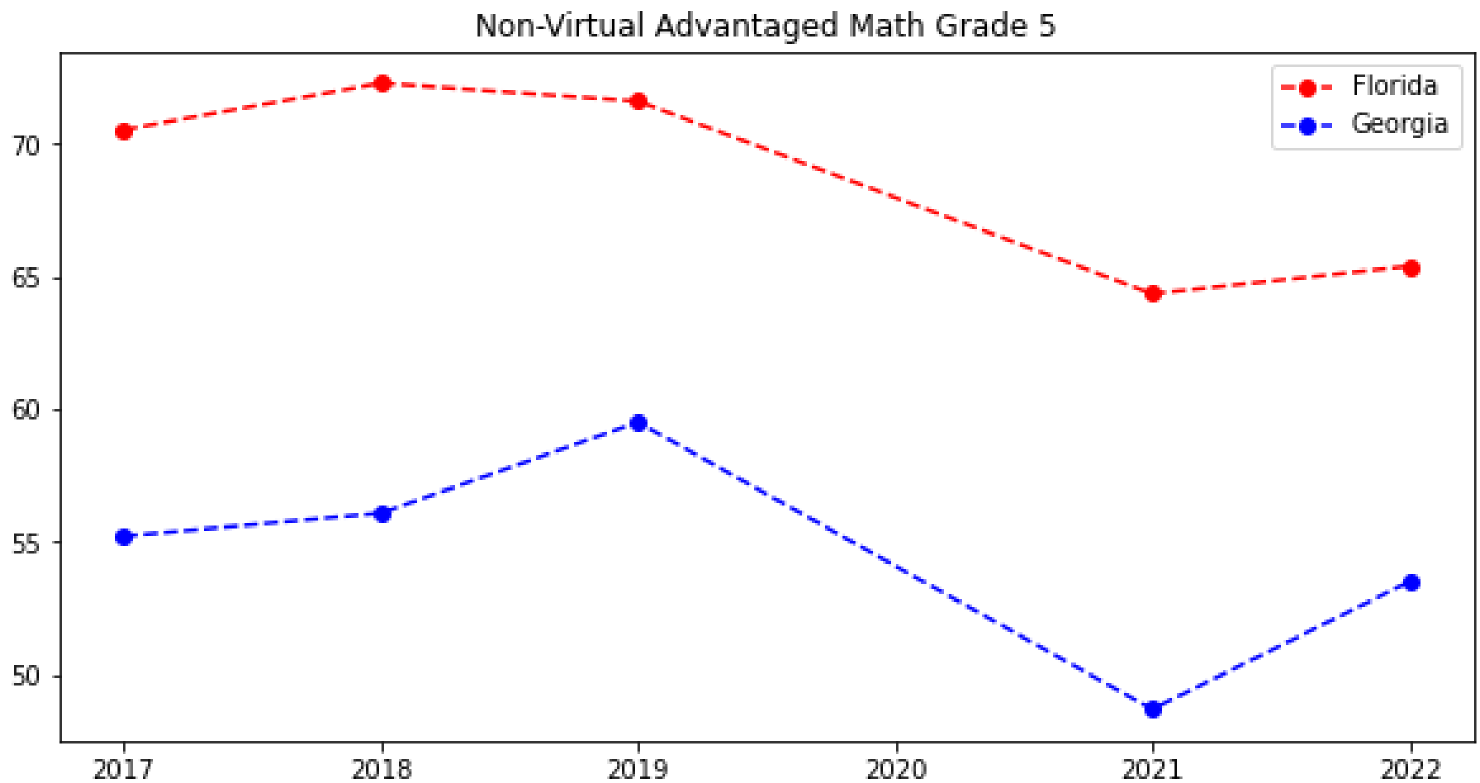
22.5
20.0
17.5
2017
2018
2019
2020
2021
2022

9.4.2 Non-virtual advantaged







Non-Virtual Advantaged Math Grade 5
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Georgia
70
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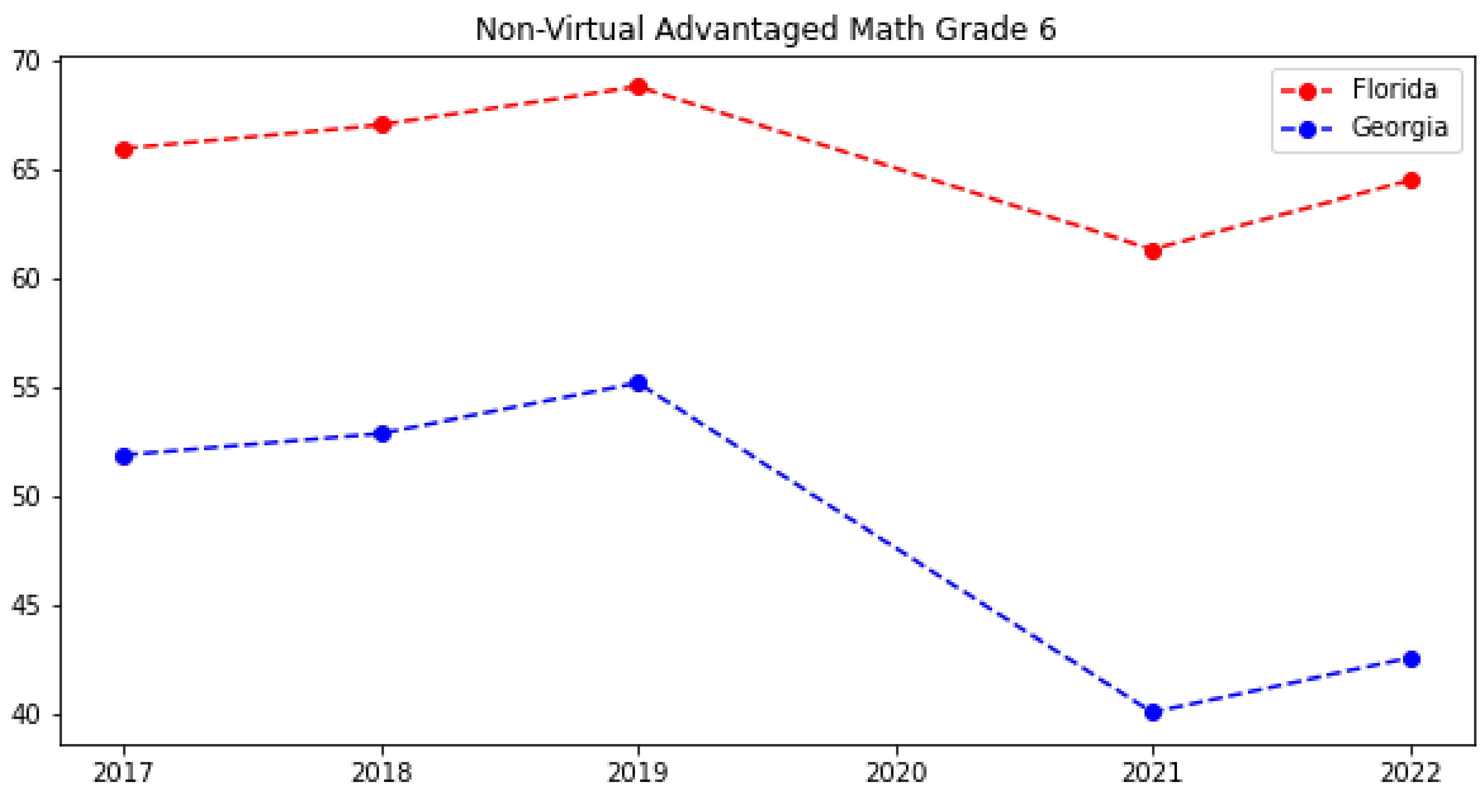
55
50
2017
2018
2019
2020
2021
2022



Non-Virtual Advantaged Math Grade 6
Florida
Georgia
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50
45
40
2017
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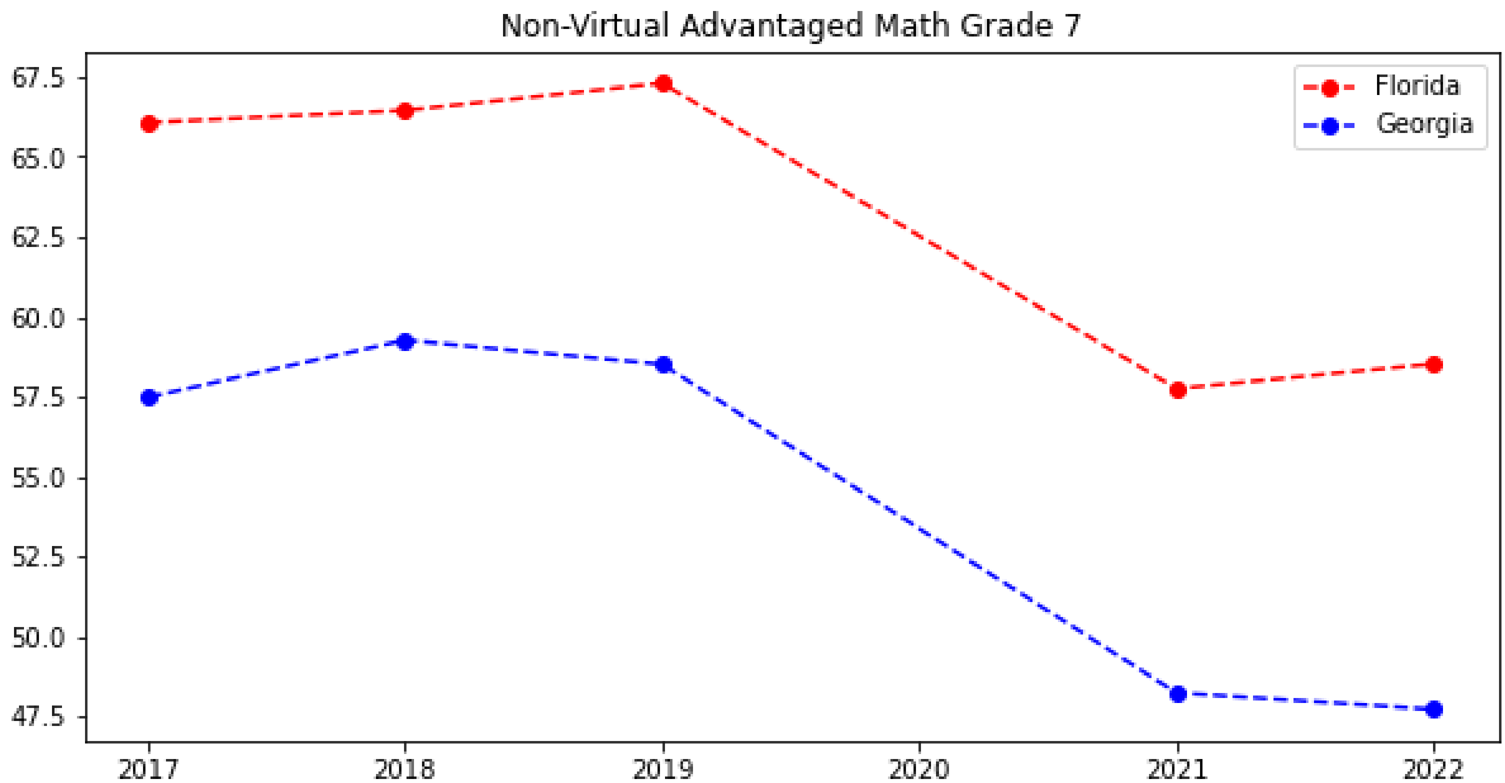
2019
2020
2021
2022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Georgia
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50.0
47.5
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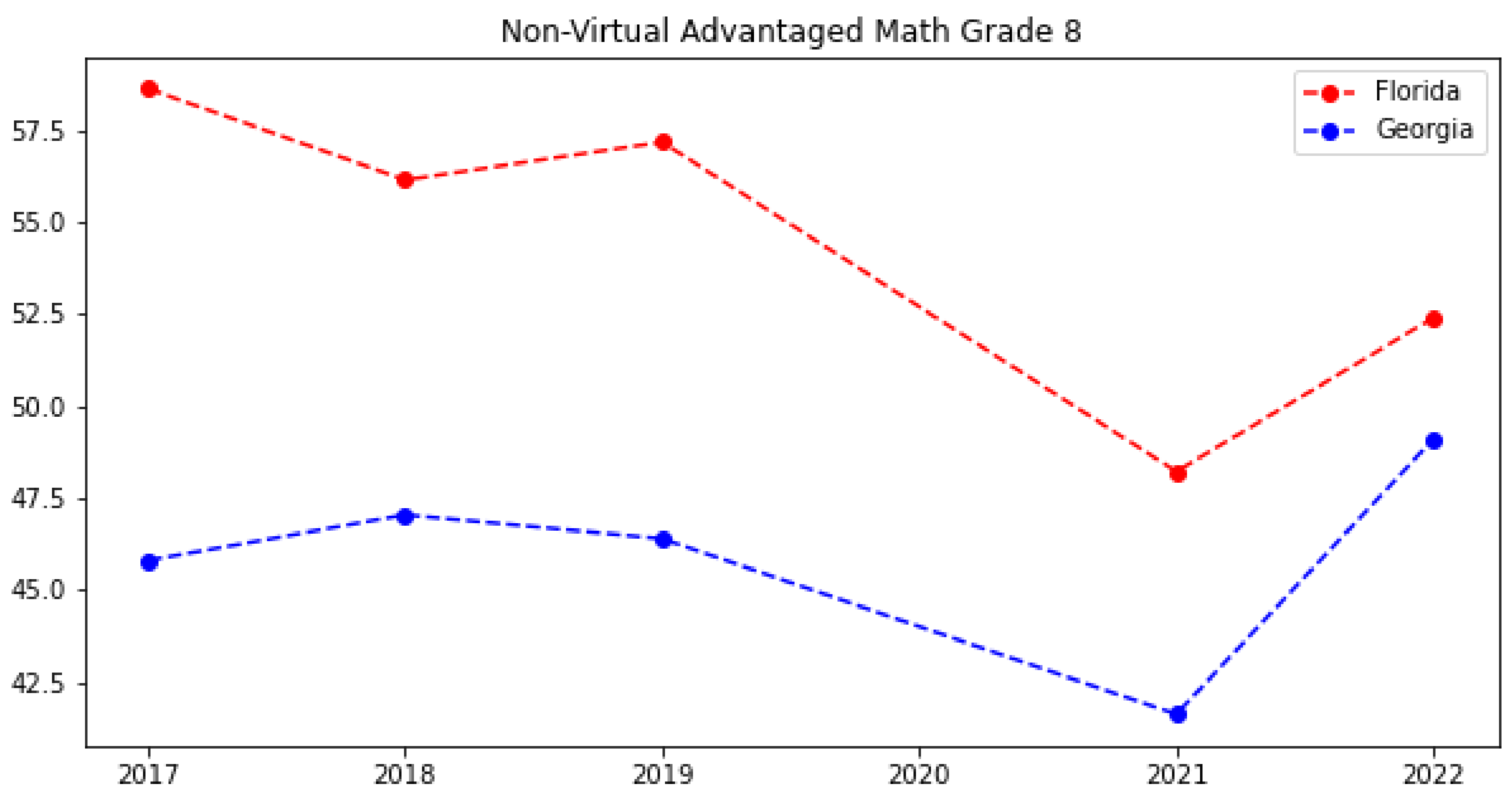
2021
2022


Non-Virtual Advantaged Math Grade 8
Florida
Georgia
57.5
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47.5
45.0
42.5
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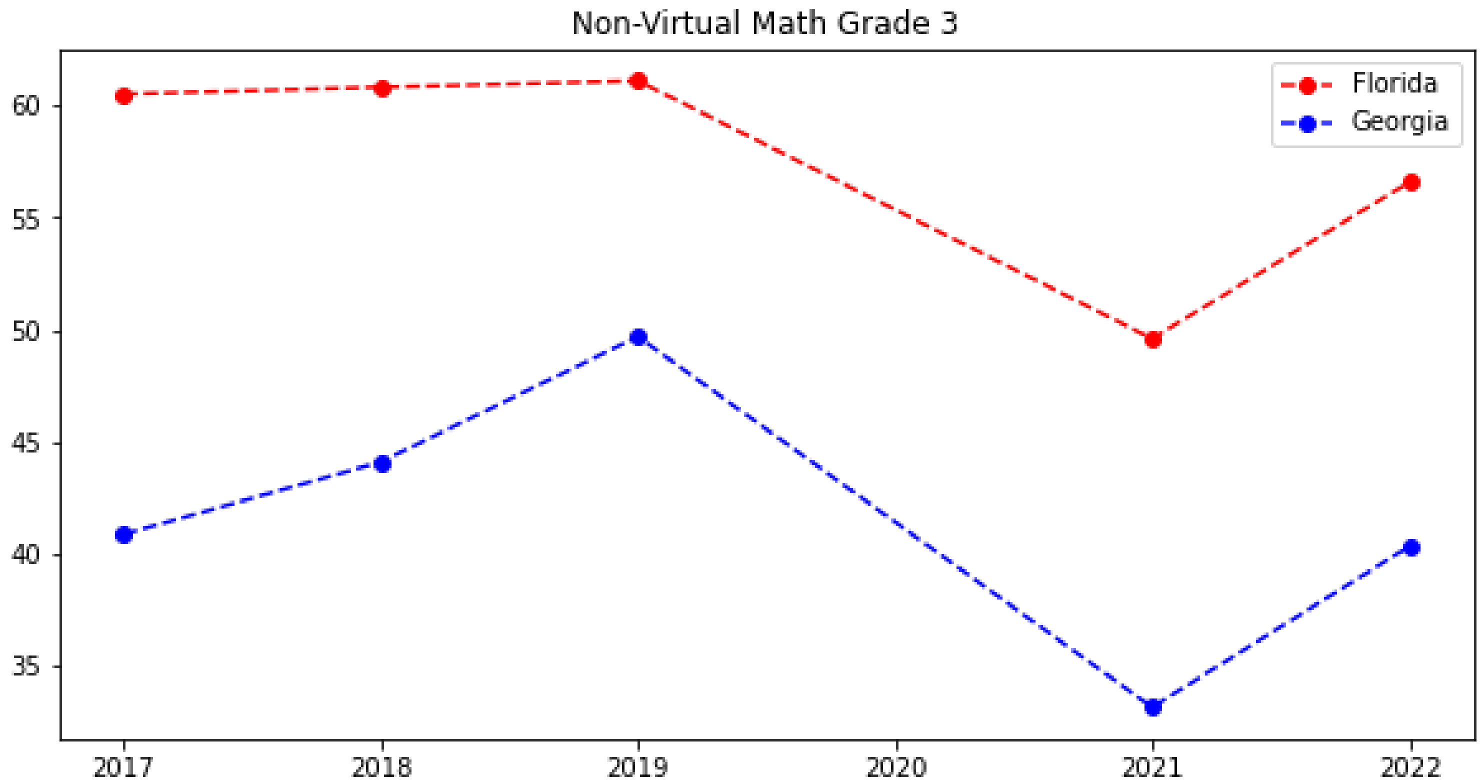
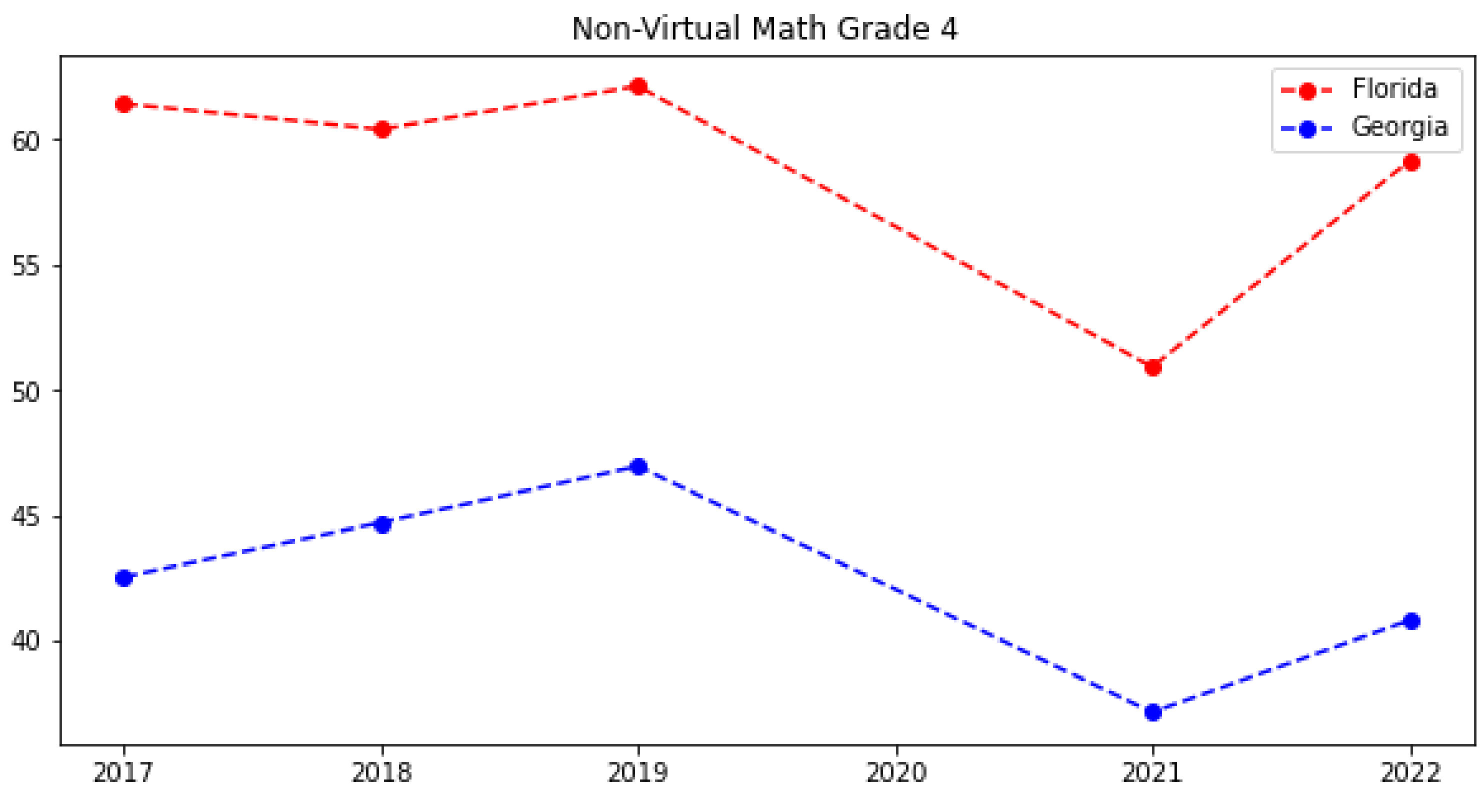
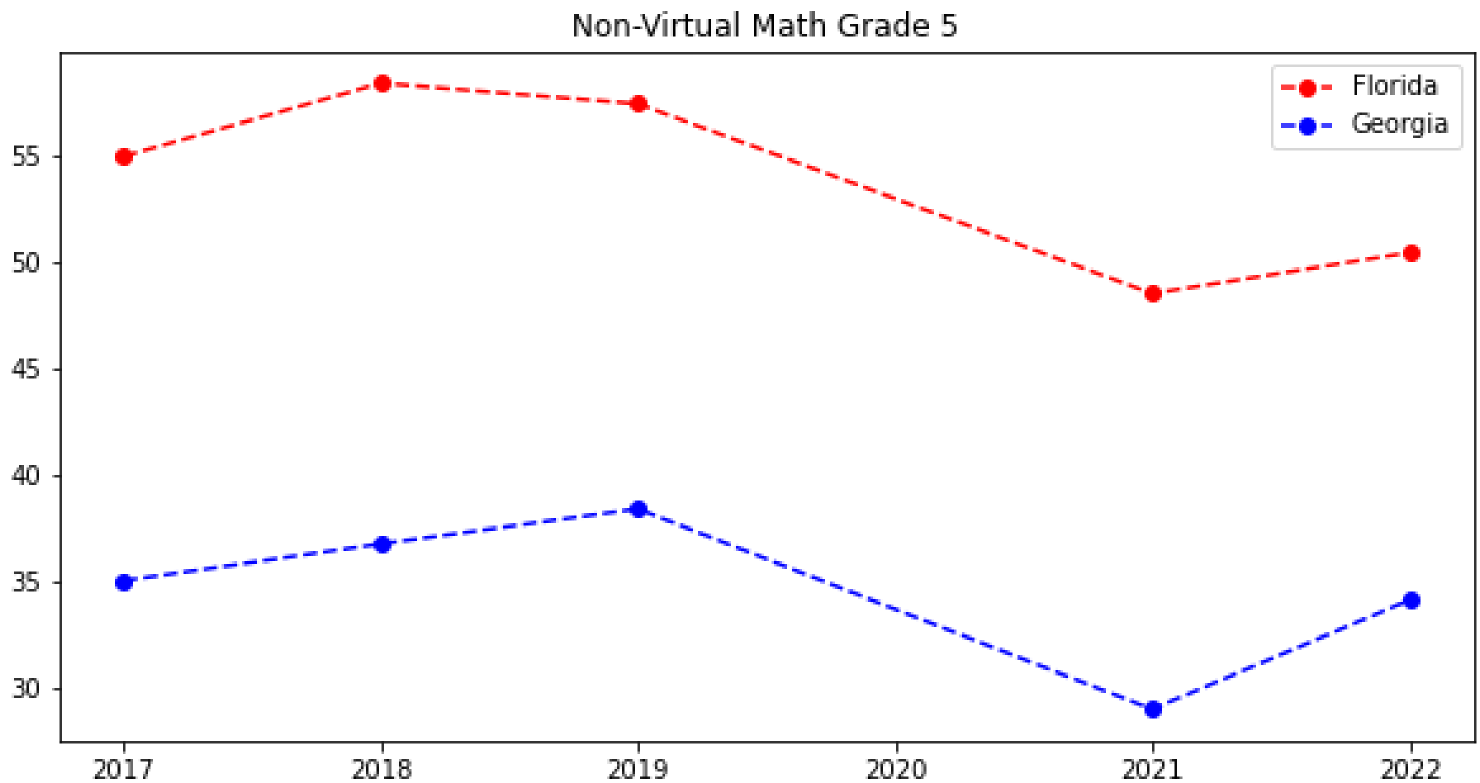
2018
2019
2020
2021
2022

9.4.3 Non-virtual







Non-Virtual Math Grade 5
Florida
Georgia
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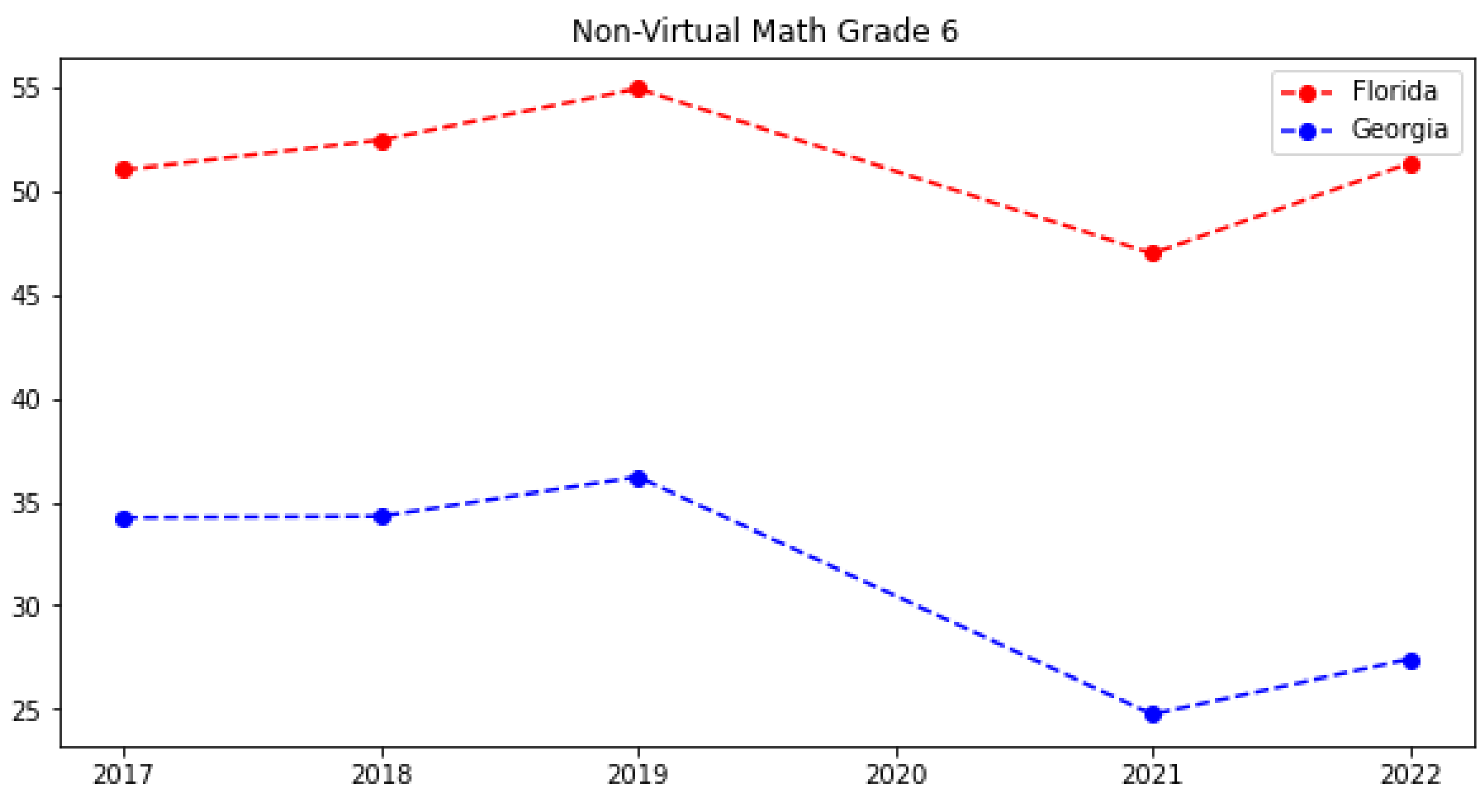
2021
2022



Non-Virtual Math Grade 6
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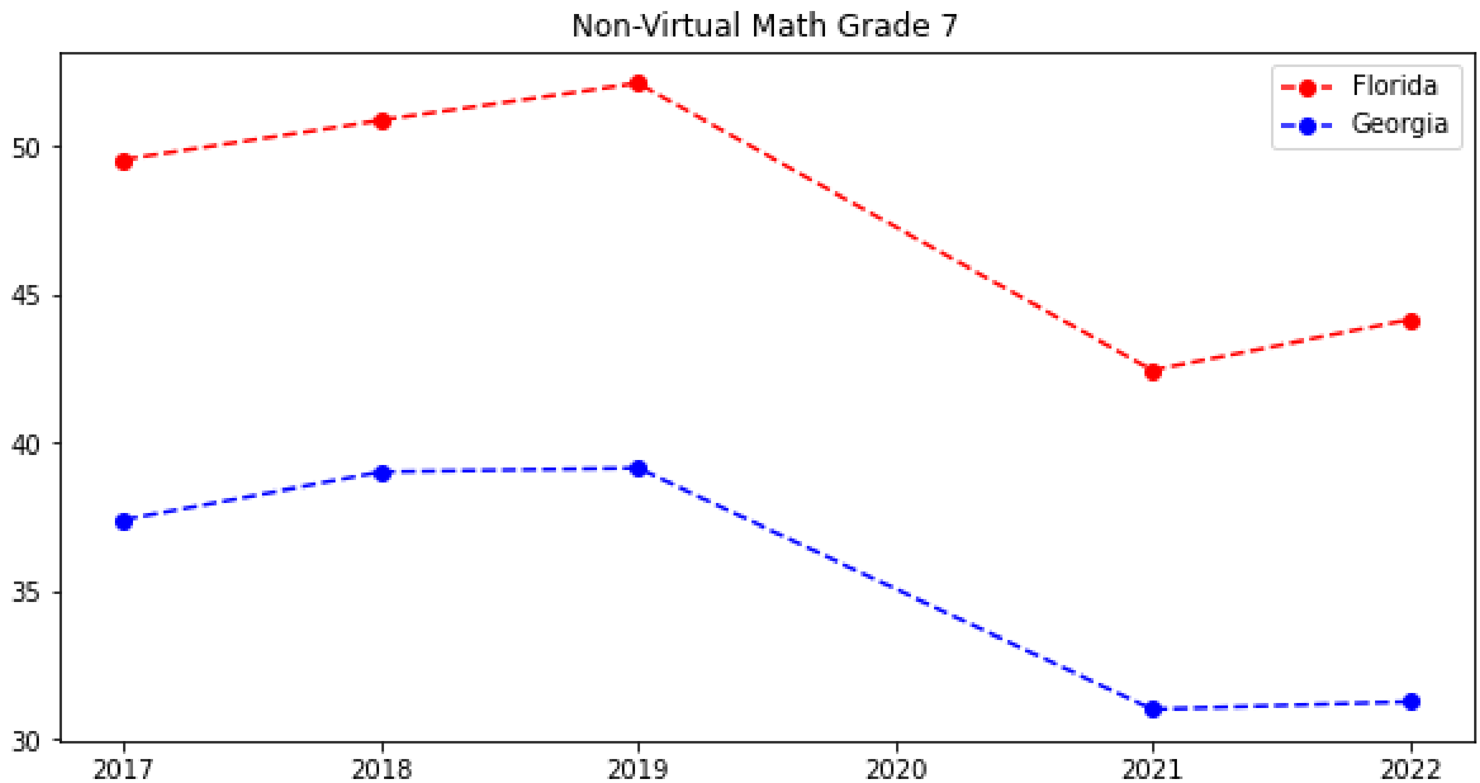
2022



Non-Virtual Math Grade 7
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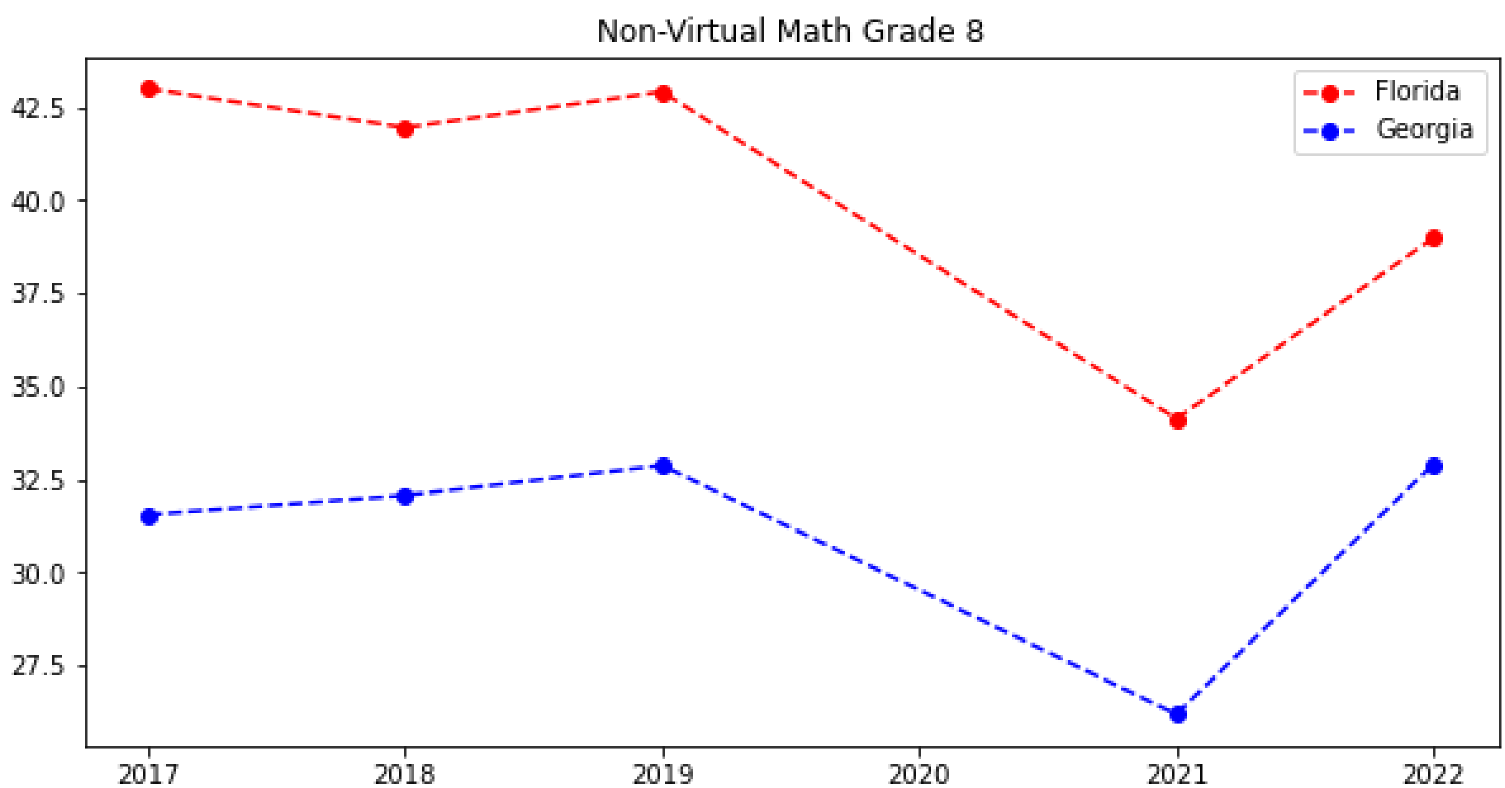
2022



Non-Virtual Math Grade 8
Florida
Georgia
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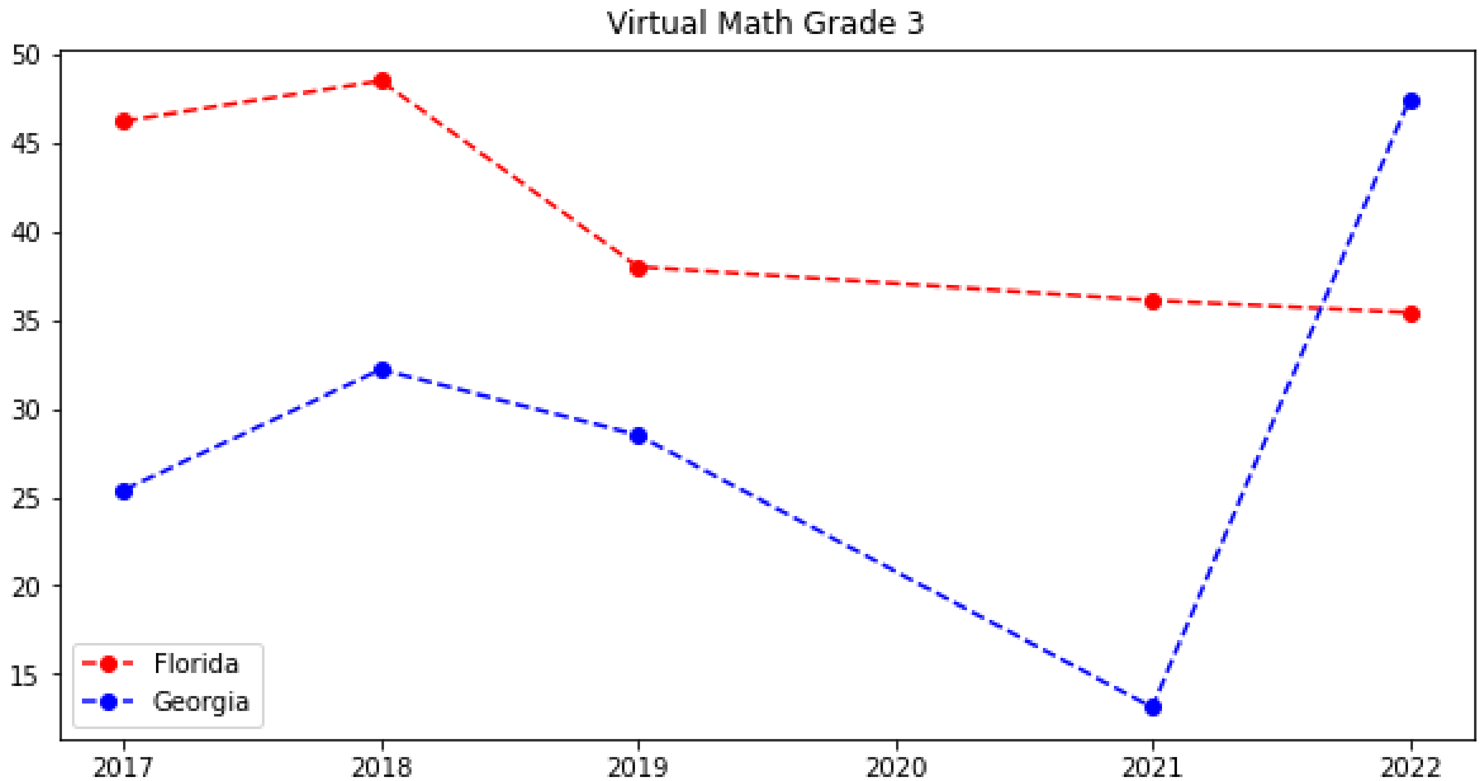
30.0
27.5
2017
2018
2019
2020
2021
2022

9.4.4 Virtual



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Georgia
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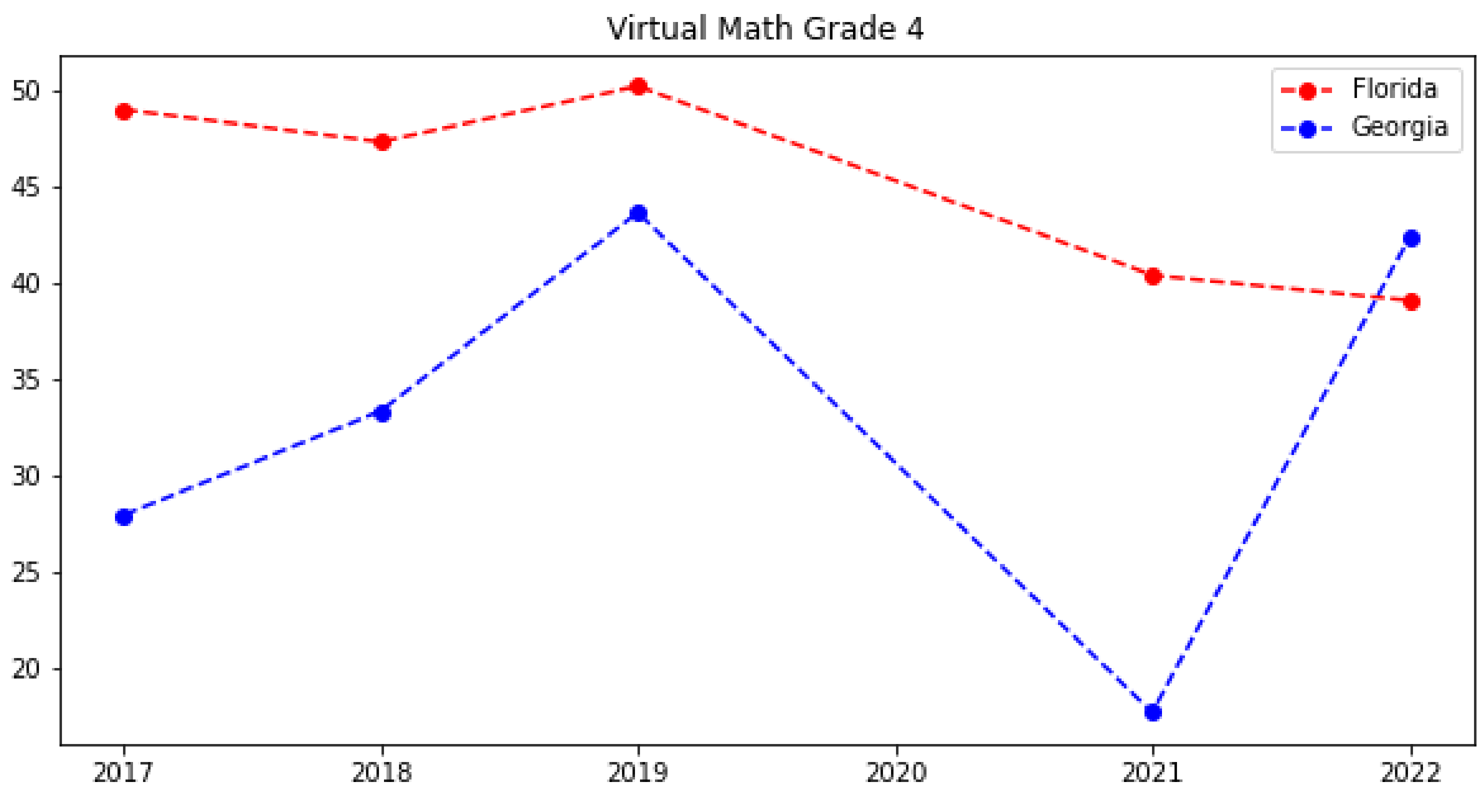

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Georgia
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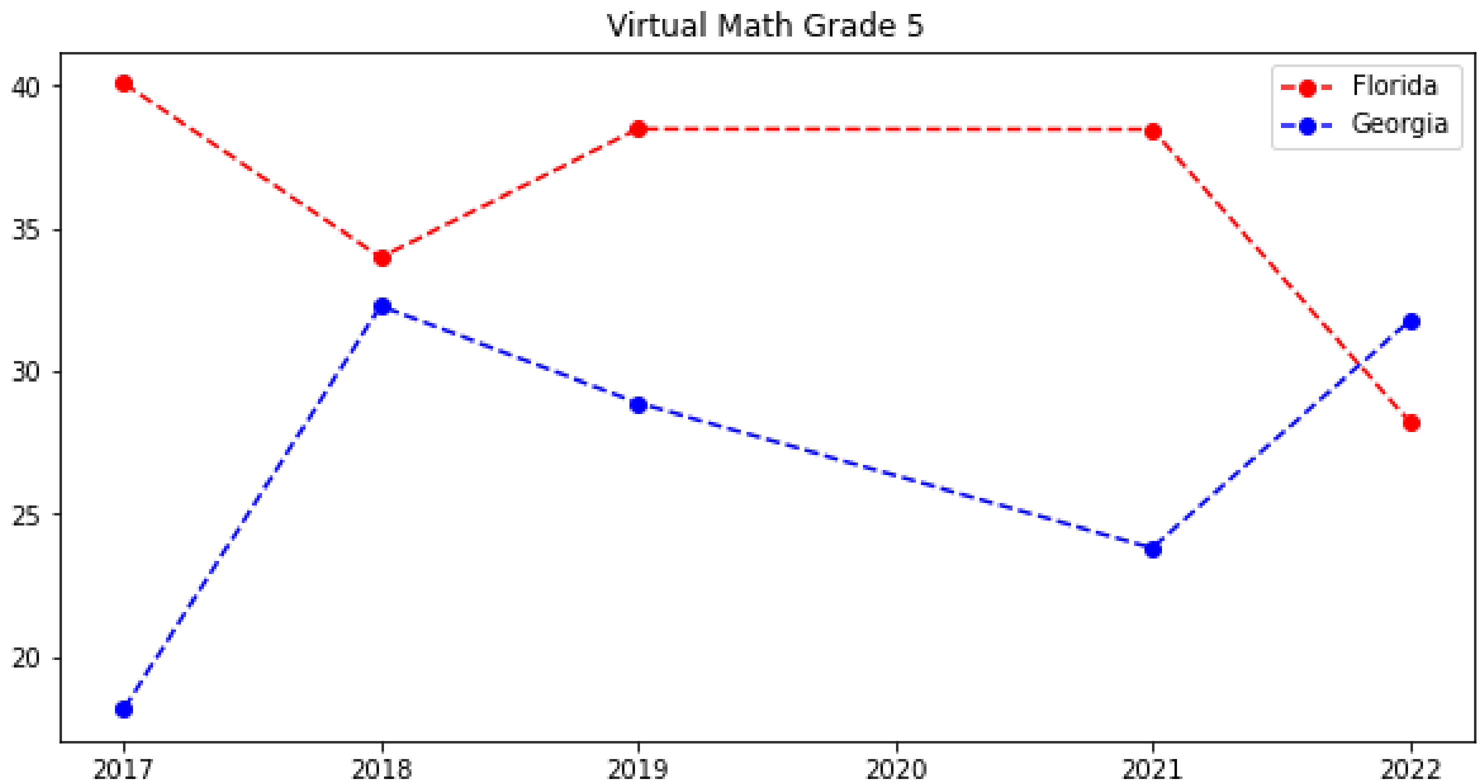
Virtual Math Grade 5
Florida
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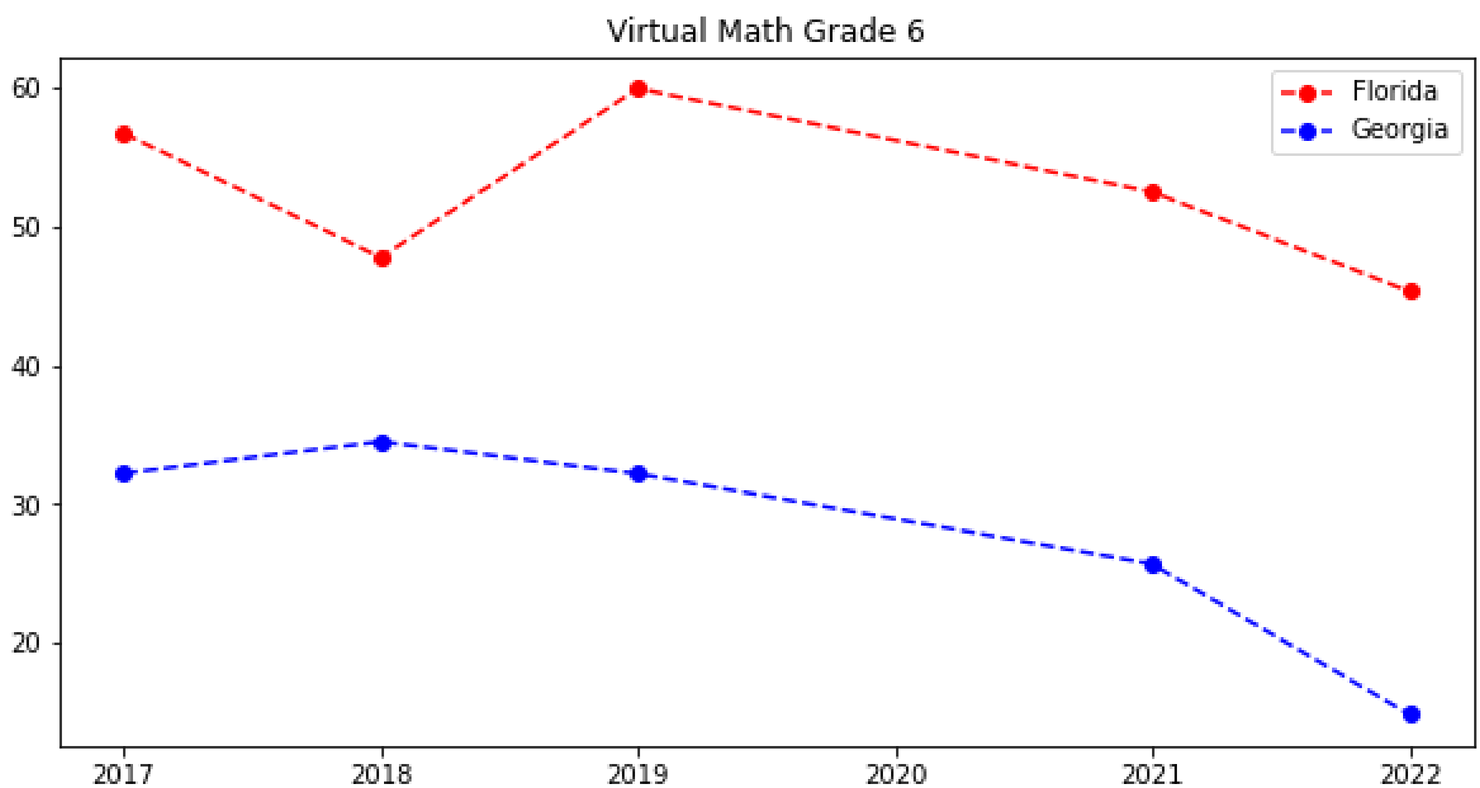
2022


Virtual Math Grade 6
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Georgia
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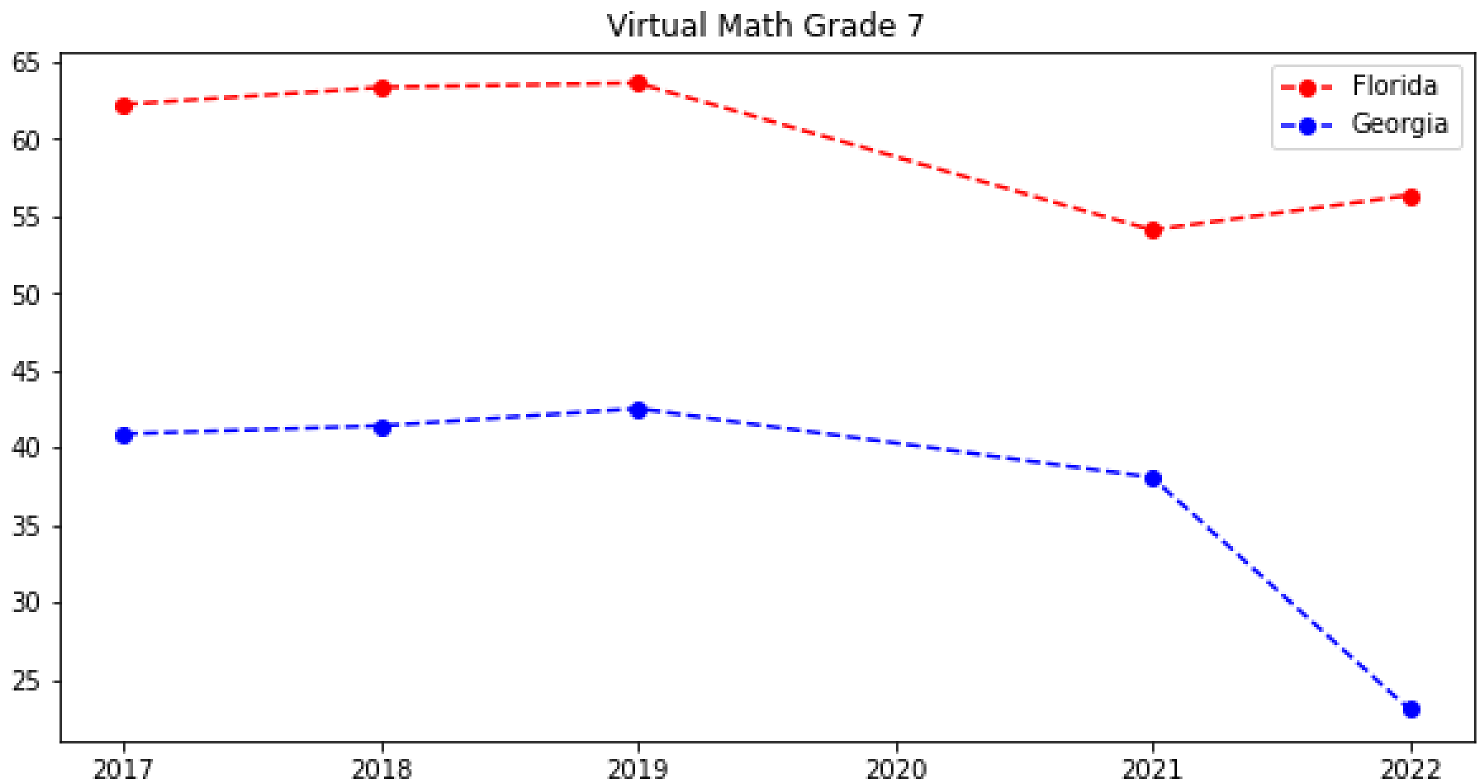

Virtual Math Grade 7
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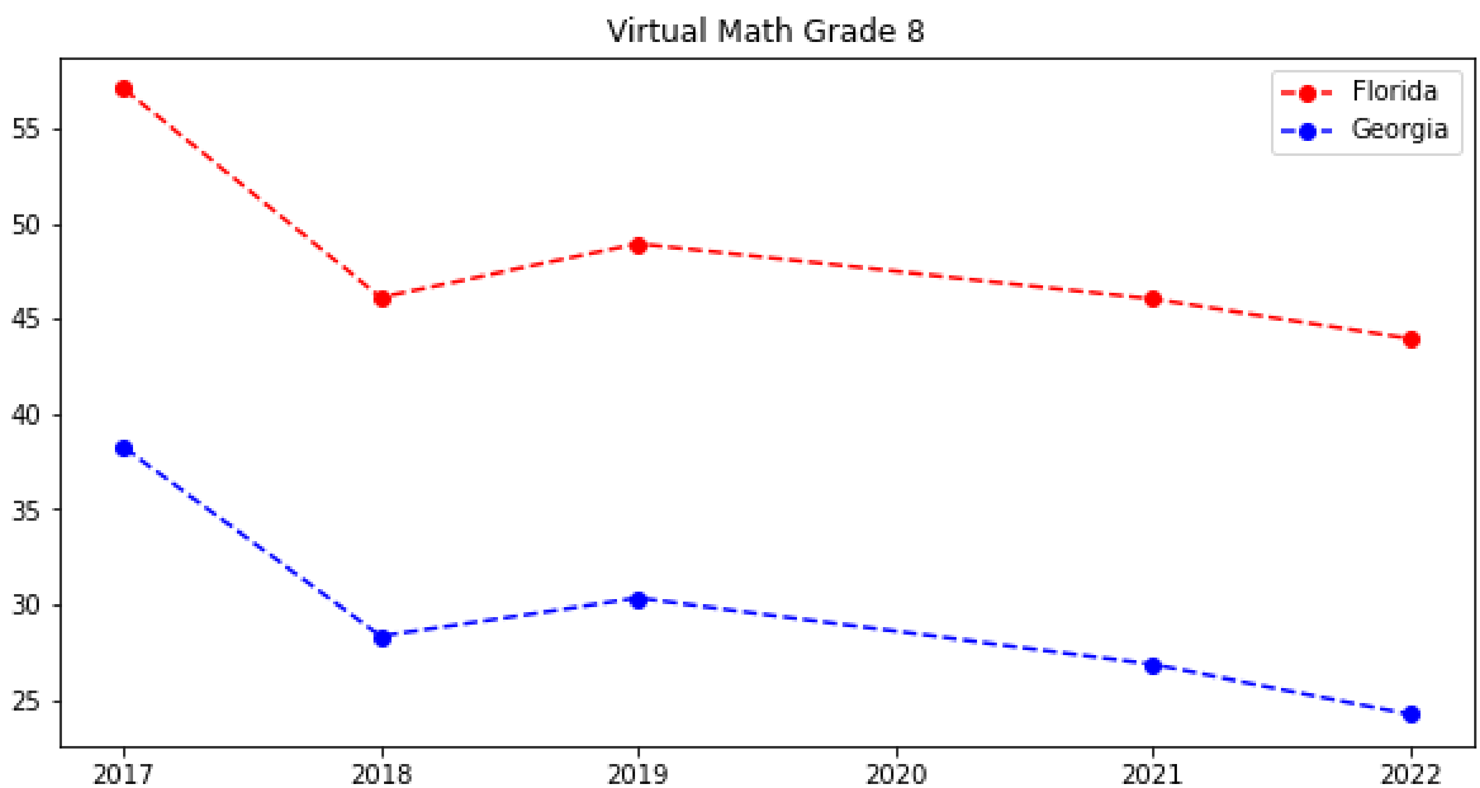

Virtual Math Grade 8
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Georgia
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2017
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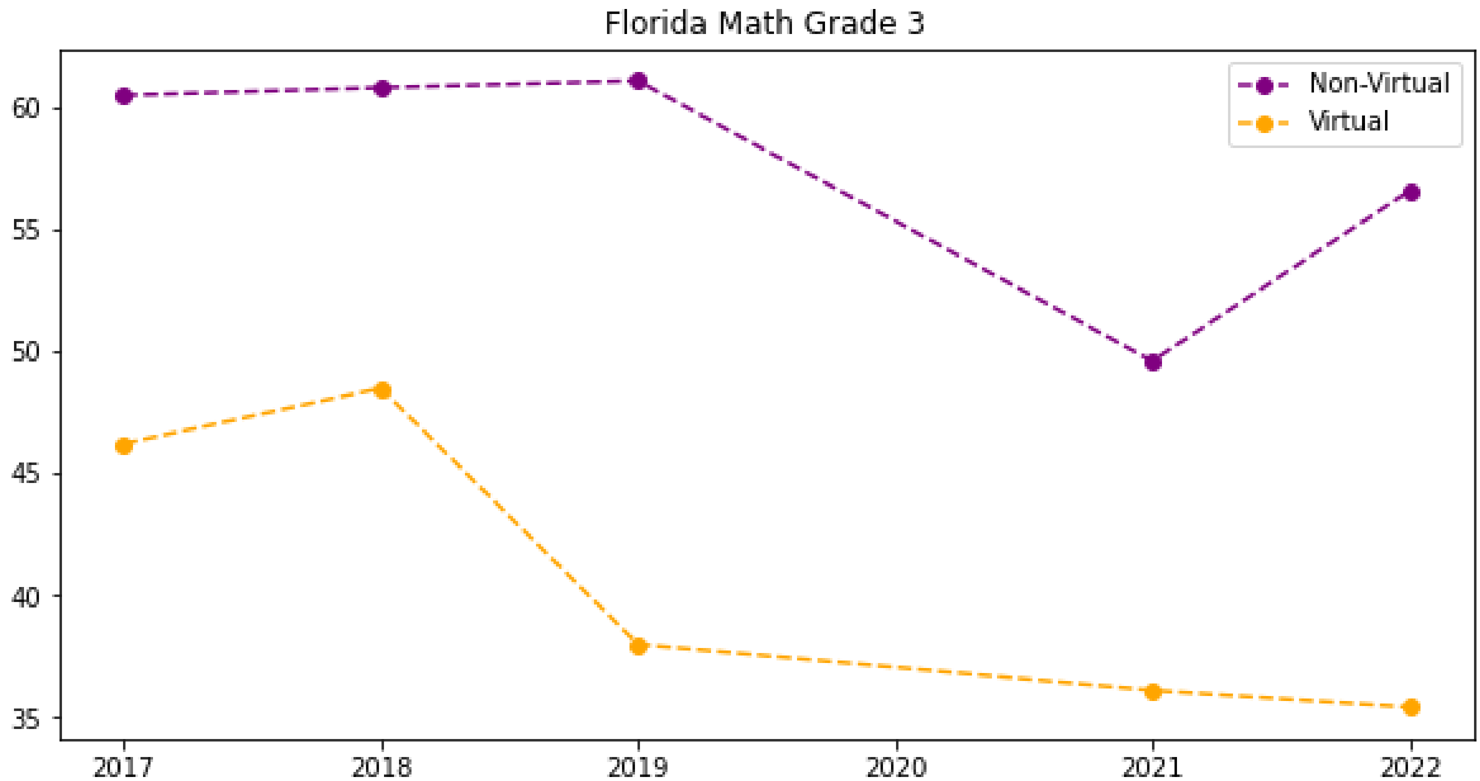
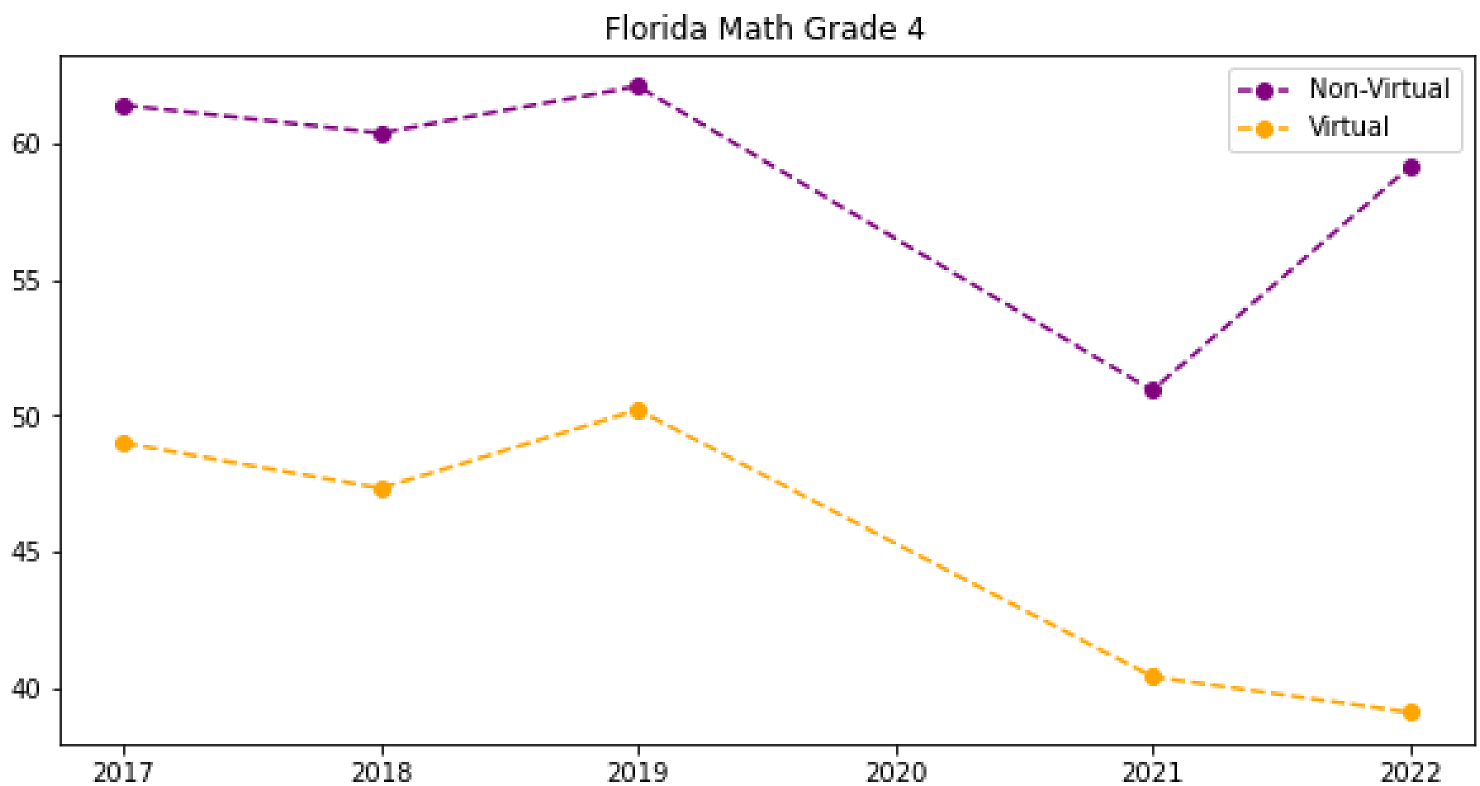
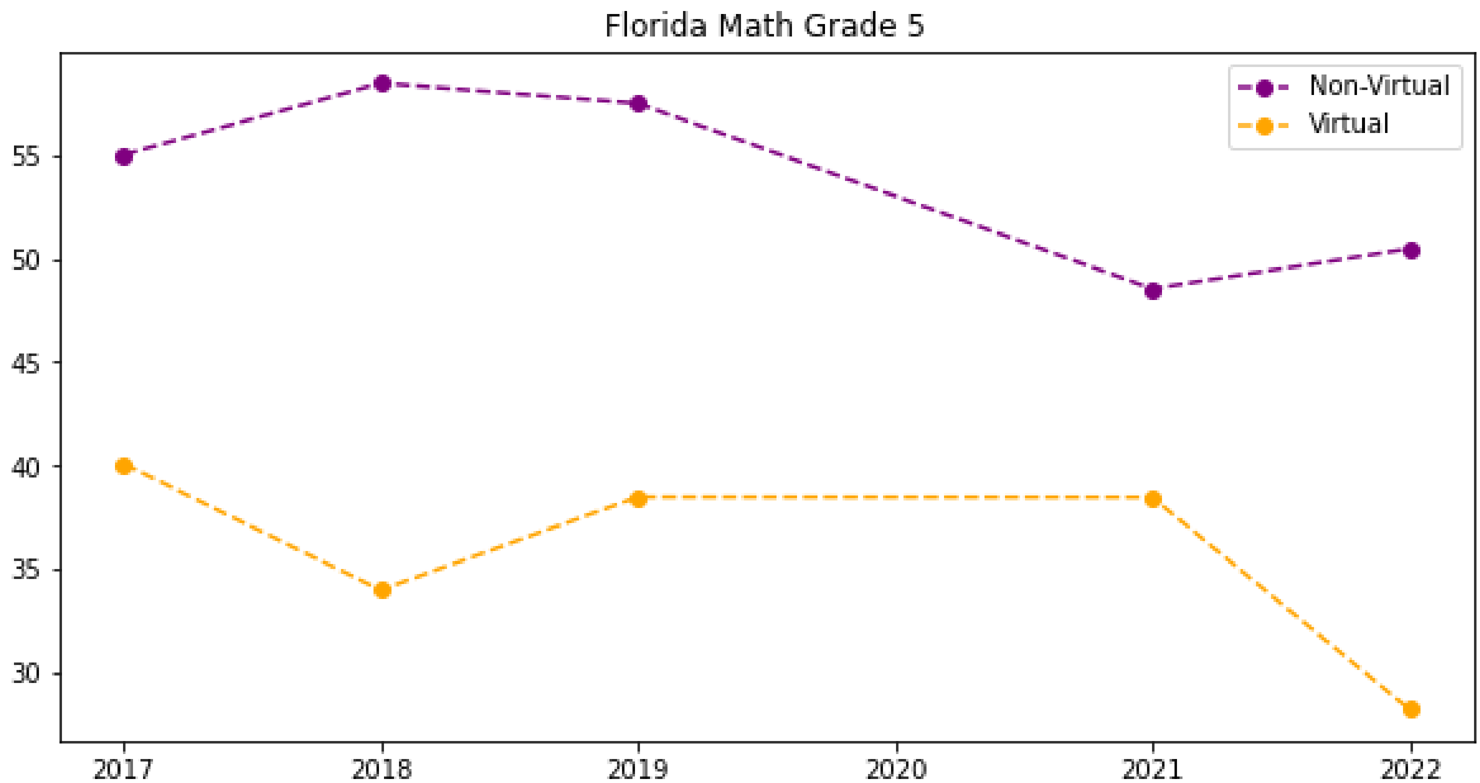
2021
2022

9.4.5 Florida virtual and non-virtual






Florida Math Grade 5
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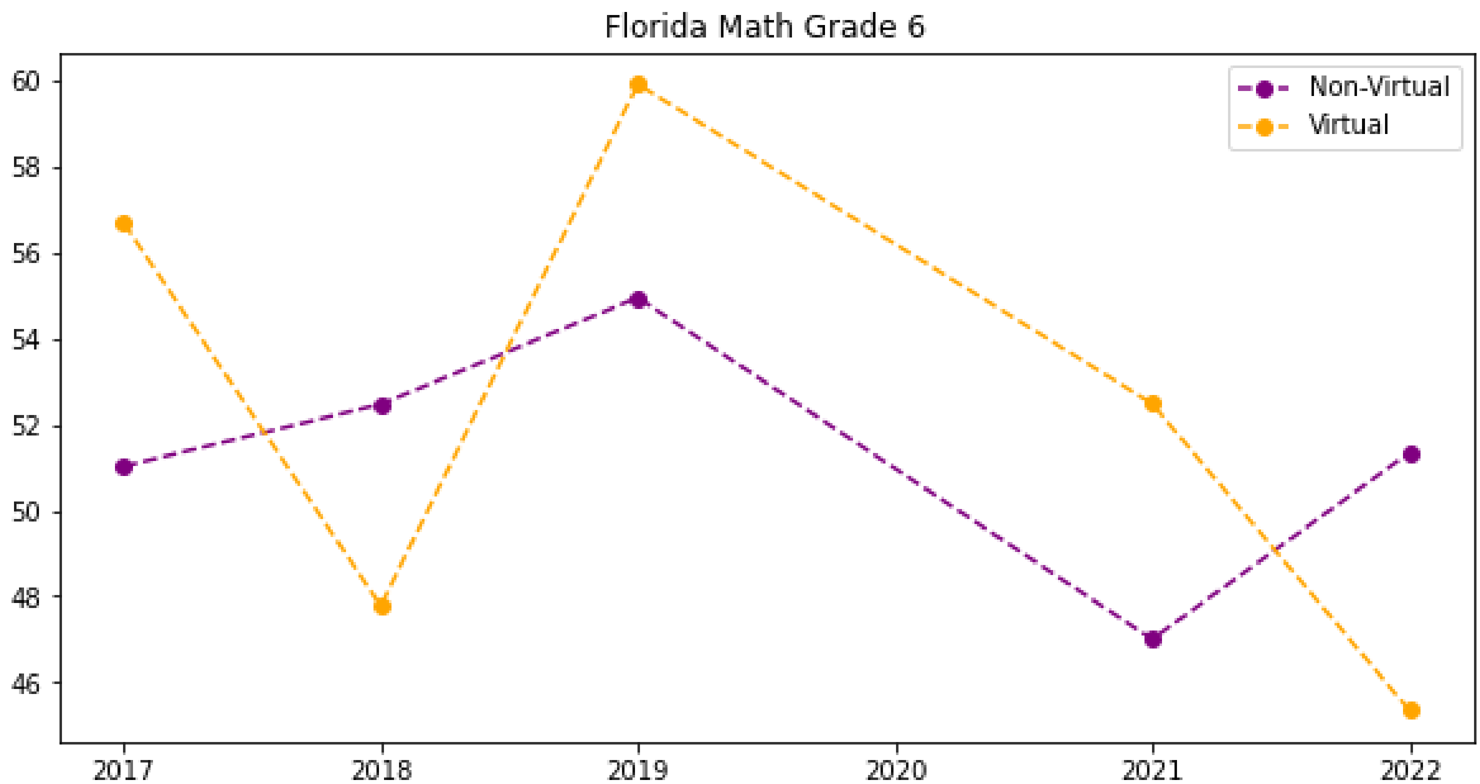
2022


Florida Math Grade 6
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46
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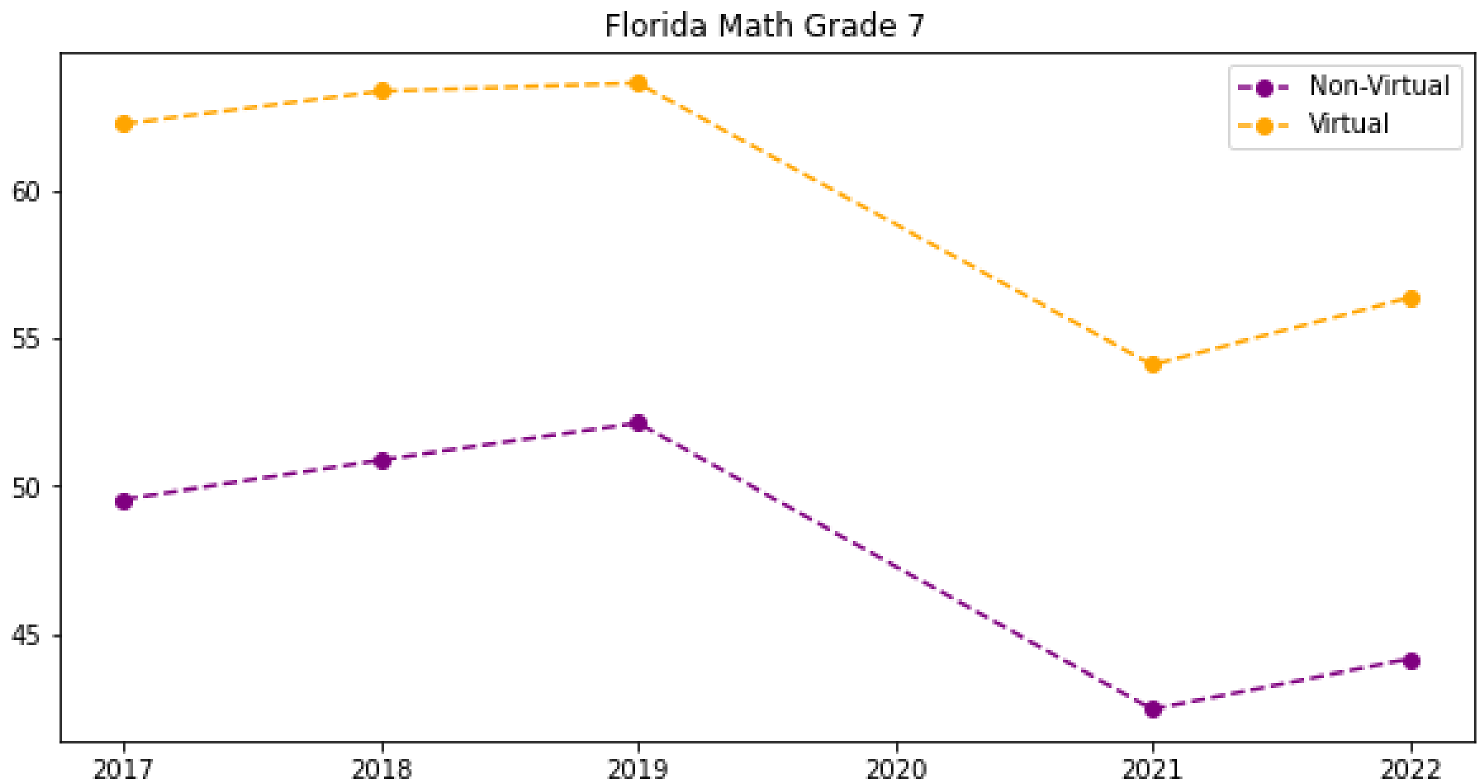
2022


Florida Math Grade 7
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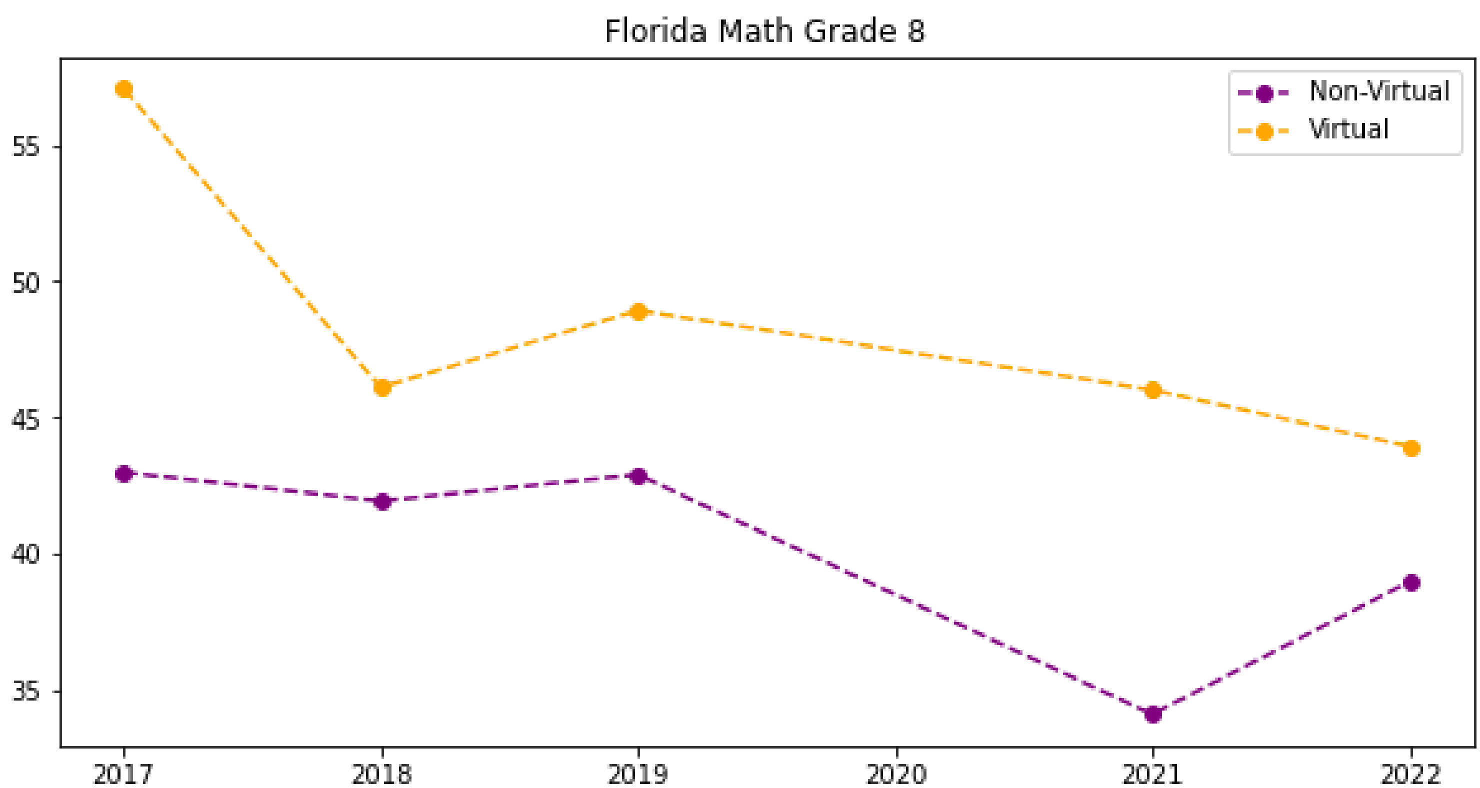
Florida Math Grade 8
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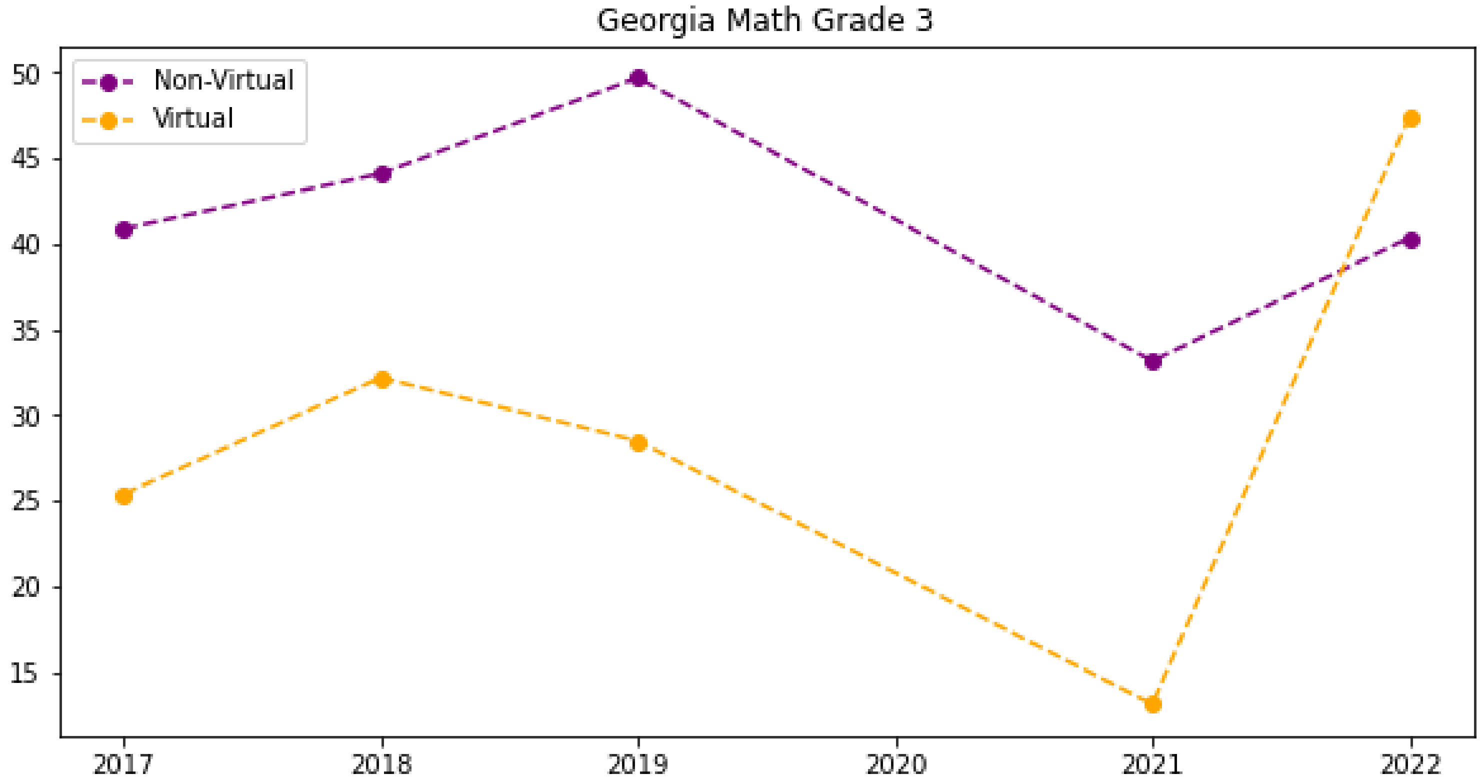
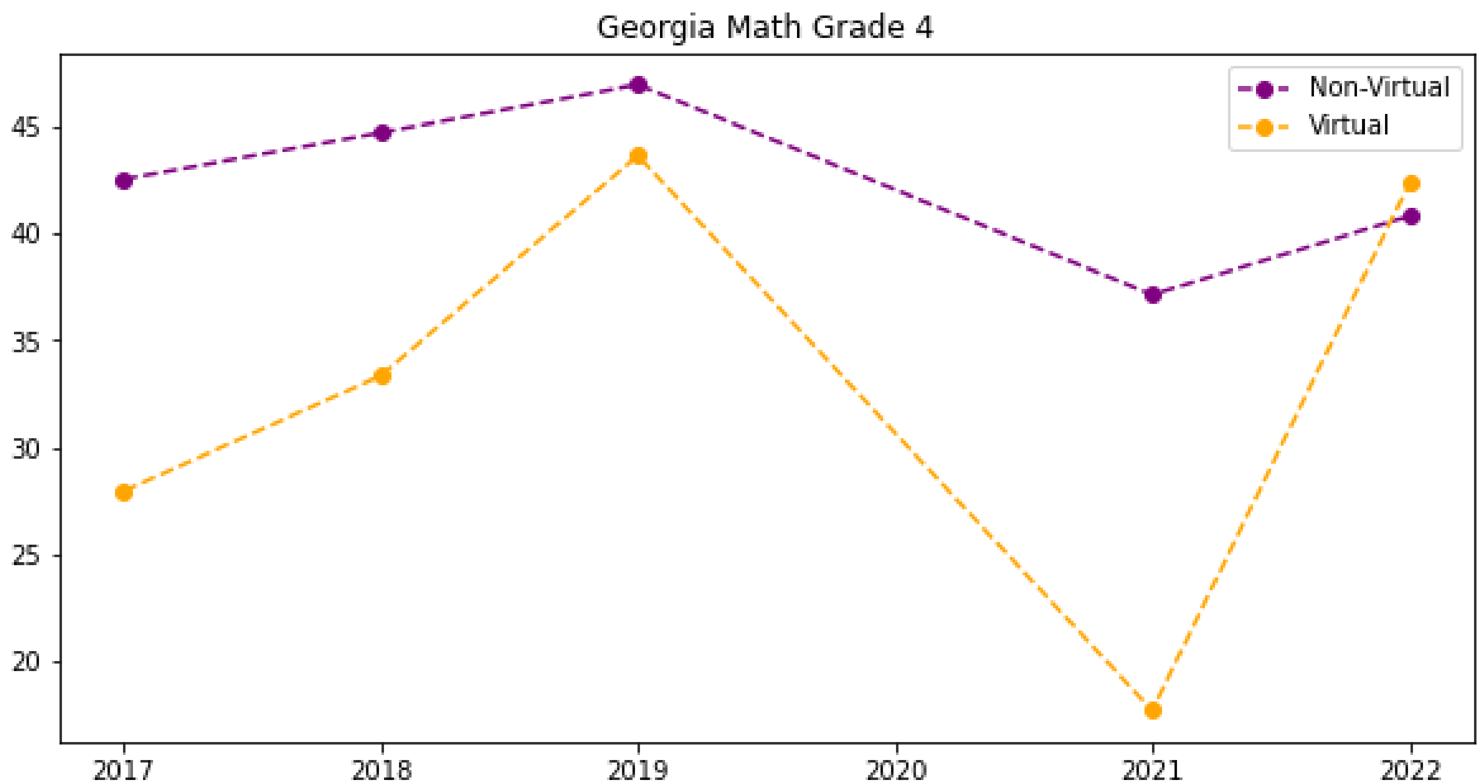
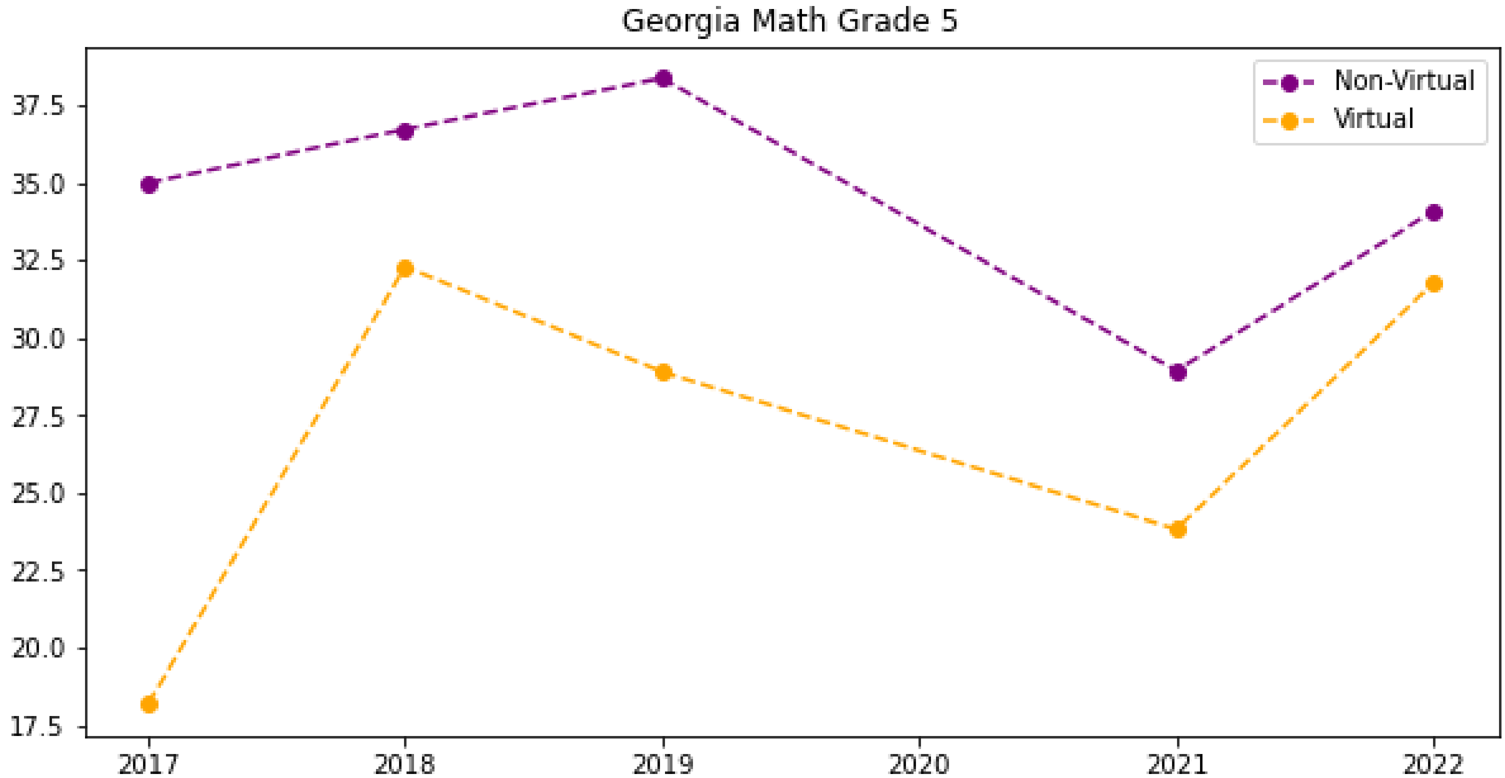
2019
2020
2021
2022

9.4.6 Georgia virtual and non-virtual






Georgia Math Grade 5
Non-Virtual
Virtual
37.5
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27.5
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20.0
17.5
2017
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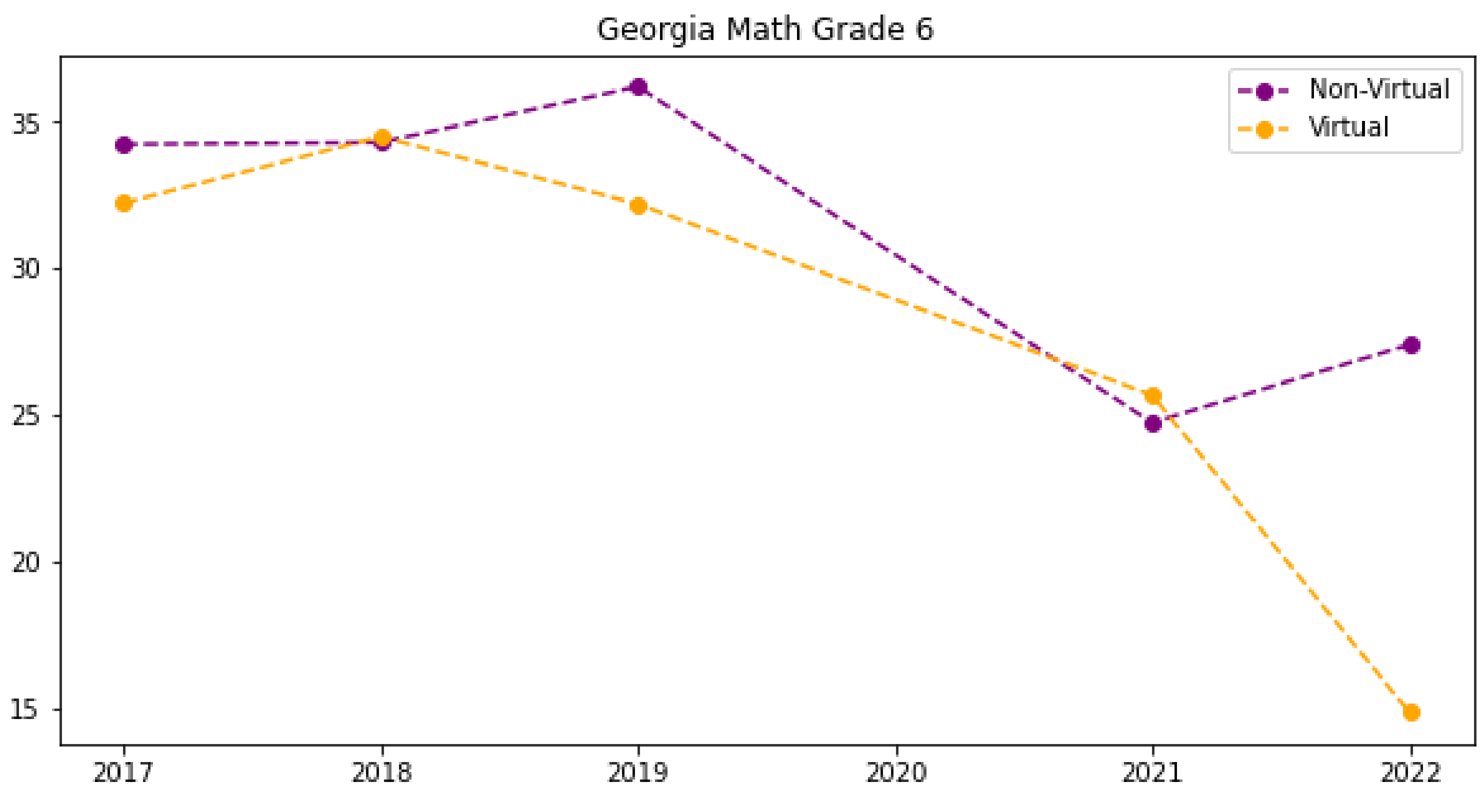
2019
2020
2021
2022


Georgia Math Grade 6
Non-Virtual
Virtual
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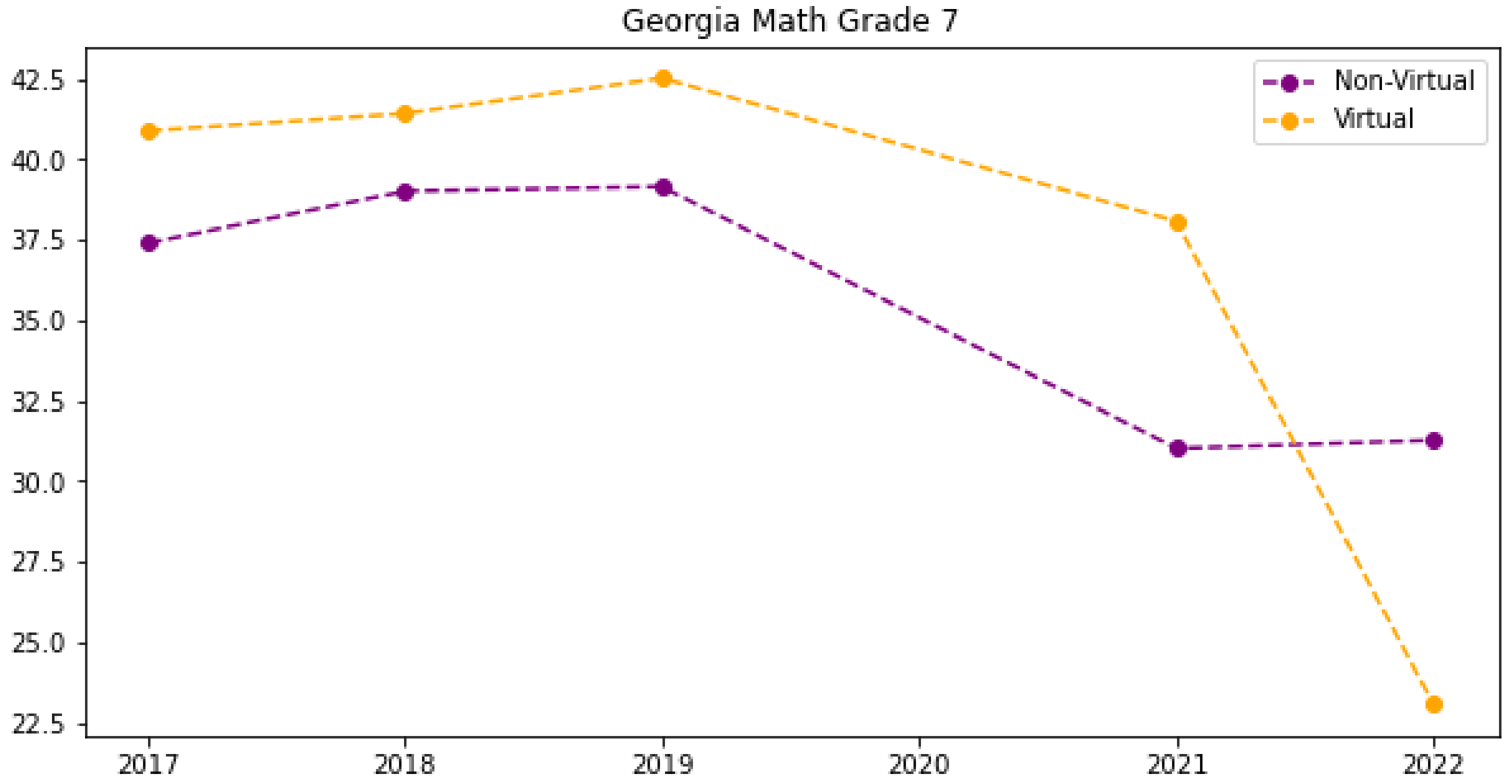
2022


Georgia Math Grade 7
Non-Virtual
Virtual
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37.5
35.0
32.5
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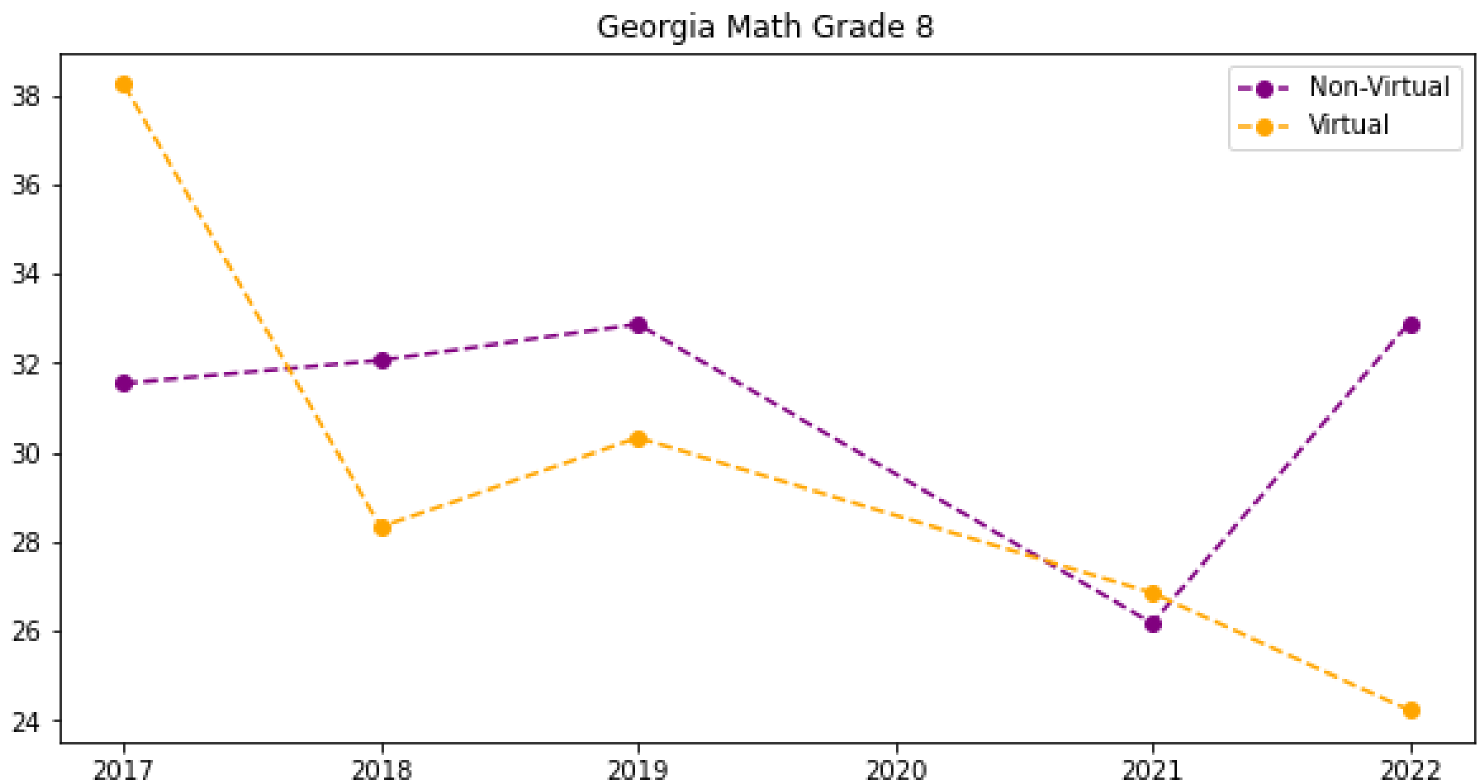
27.5
25.0
22.5
2017
2018
2019
2020
2021
2022


Georgia Math Grade 8
Non-Virtual
Virtual
38
36
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2017
2018
2019
2020
2021
2022